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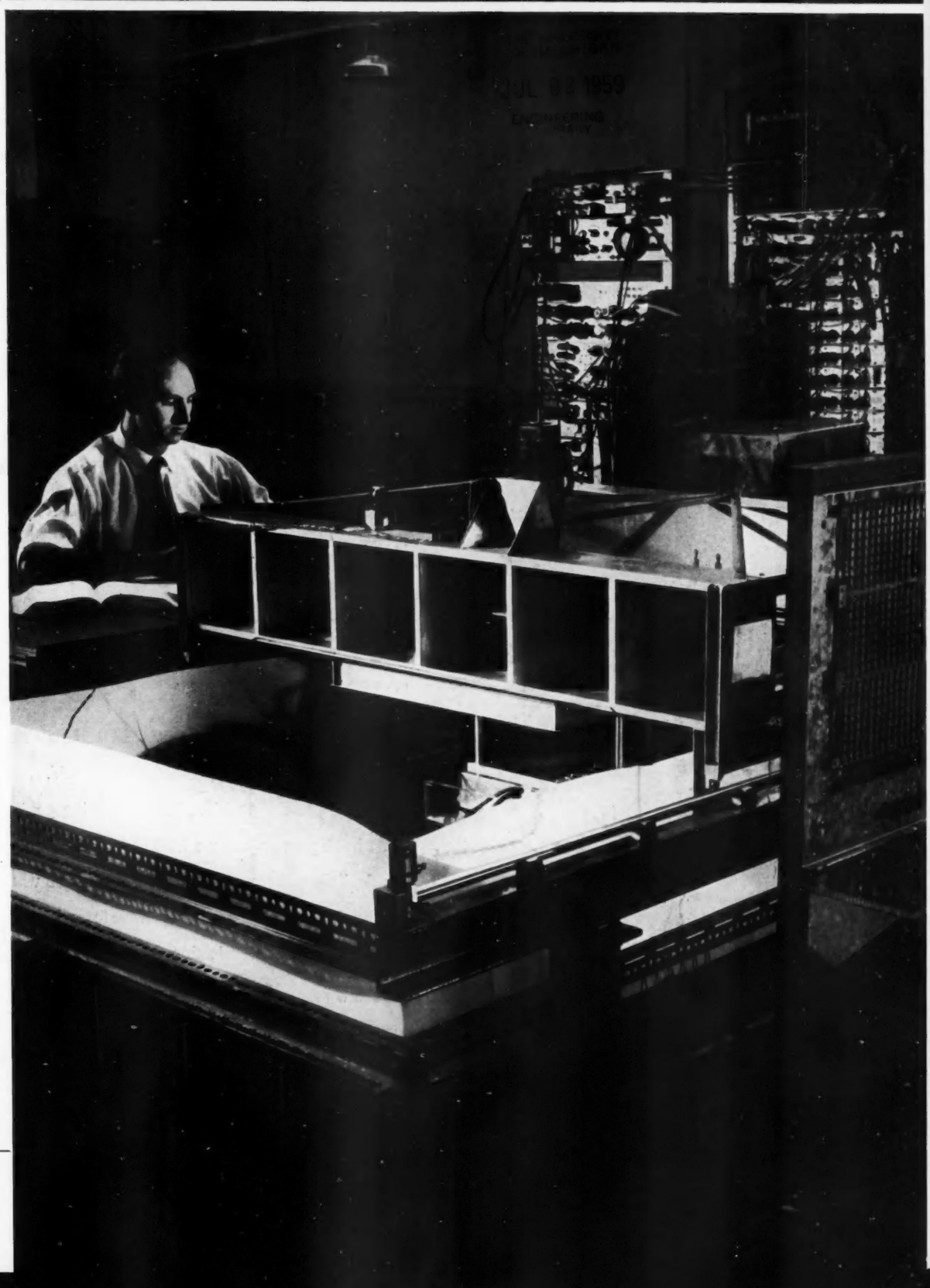

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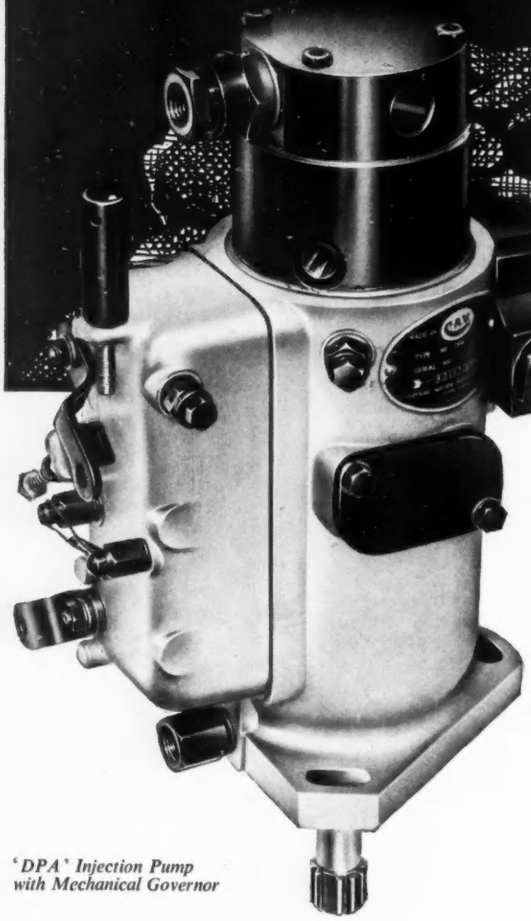
"Hounds in Leash." After the sculpture by Harry Bates



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Wrong Target

ARE the ideas on which British, Continental and American nuclear energy programmes have been based already out of date? Have we slipped into a complacent nuclear rut, in which the recital of target figures replaces thinking? These questions were the burden of a recent talk by Mr. Robert McKinney, editor and publisher of the *Santa Fé New Mexican*, to the Parliamentary and Scientific Committee in the House of Commons on 3 June. His first conclusion was that the joint United States-Euratom programme for industrial nuclear power is not now likely to develop at a pace that will pay material dividends to American industry. In other words, the prospect that the Euratom countries would serve as a testing ground by American nuclear firms is off. The pace at which the Six now wish to develop their nuclear power programme will not be fast enough to keep up with, let alone act as a pilot for, the American nuclear industry. What has brought about this change?

Euratom originally had two main objectives: first, research and exchange of information; and second, the development of investments, common installations, the supply of nuclear fuels and other overhead services. These objectives were both valid back in May, 1956, when the Brussels Report was drafted. But after that came the Suez incident. A new appraisal was made and the " three wise men " in *Target for Euratom* called for the creation of 15 million kW of atomic electric generating capacity by 1967. At that point there was no coal surplus and the chances of Europe remaining short of dollars and becoming increasingly vulnerable to the interruption of fuel imports were odds on. In this situation Euratom seemed to offer a way out to the high-cost energy economies of the Six, one in short that would conserve foreign exchange and provide an alternative power source competitive with fossil fuels.

The United States agreement with Euratom committed between 400 and 500 million dollars in money, material and guarantees as a first-step atomic goal of one million kW by 1963. Mr. McKinney believes that the reasoning behind this action no longer holds good. He argues that the target of 15 million kW of atomic electric power by 1967 should be reexamined. The dollar shortage is no longer acute and there does not seem to be any energy gap in either the short or middle term that cannot be bridged by coal or oil. The long-term position is more speculative and here there is clearly a great deal of sense in continuing research and development in the hope of realising competitive atomic power.

Does all this mean that in the name of progress we have been spending enormous sums and despoiling our countryside all for nothing? Mr. McKinney still believes that nuclear power is the logical new energy source. New inventions may bring great new developments in this field. But in the meantime research and engineering work will be concentrated on conventional nuclear reactors. Will European business men consider that the technical return in operating experience from a Continental reactor complex generating one million kW by about 1963 justifies its cost? Mr. McKinney argues that such a programme places more emphasis on atomic electric power generation than the situation justifies.

But apart from power generation, Euratom has an important role to play in the integration of European science and technology. Is it equipped to do this? Mr. McKinney points out that the United States has about the same number of each type of particle accelerator as the rest of the world put together. In the nuclear field there is an increasing number of experiments in which the limiting factor is the availability of a large staff embracing many special skills and having expensive special purpose facilities at their disposal. In the changed energy situation the operative idea behind Euratom should not be atomic kilowatts but the integration of European scientific and technical research. Mr. McKinney would like to see Euratom develop into an organisation centred on a laboratory equipped with nuclear and other facilities open to qualified people from the 15 nations of the Atlantic Community.

There are many difficulties in the way of revising Euratom's role. Certainly Britain cannot take any initiative in this without arousing grave suspicions in Brussels and Paris. But Mr. McKinney's argument makes sense. Euratom was created to solve fuel and dollar shortages that have resolved themselves. The big tasks are now in bringing about scientific and engineering advances which will require the capabilities of larger units. Will it be possible to expand Euratom by bringing in other Western European nations, or otherwise to rationalise the present overlapping bodies?

We regret that the publication of Engineering is temporarily suspended, after this issue, because of the labour dispute in the British printing industry. We offer our apologies also for the reduced contents of the present issue, but we hope to resume normal full publication in the near future.

Cover Picture.—*The design of devices using electron beams is hampered by the difficulty of determining electron trajectories in any but the simplest of electric and magnetic field configurations. An automatic trajectory tracer has been evolved at the Cambridge University Electricity Laboratory which uses a highly accurate form of electrolytic tank and a small digital computer.*

(*Nurnberg photograph for* ENGINEERING)

Plain Words

Maybe every 10 years something will go wrong with a nuclear power station. Then, and only then, will a highly qualified resident engineer, a man of great ability and profound education, be called upon to put his training into practice. On his decision may depend the health, even life, of a thousand or a million people. Until then he sits and waits. The age of instrumentation brings new hazards.

One company at least appears to be taking the matter seriously. The General Electric Company have begun a study to discover how people can best cope with the exacting work in nuclear power stations. Mr. Derek Howse, head of the company's new human factors section, is reported to have said: "The more safety you require the more you tend to mechanise. A lot of our difficulties in future may spring from the fact that the control of a power station is much more mechanised than usual; the problem is to know when to step in." Dr. J. D. Abbatt, head of the radiobiology department, commented that "you cannot run an atomic power station with a test pilot . . . What we have to do is design plant for control by human beings."

Instrumentation was recognised by Mr. J. F. Coales in his recent presidential address to the Society of Instrument Technology as a fundamental engineering discipline, if not quite a fourth—or is it fifth—primary technology. His arguments were convincing, but whether they prevail or not, instrument engineering is bound to affect our way of life, and not only through automation and the new balance of qualified manpower that the growth of instrumentation will demand. Rather I am thinking of the way such manpower will be employed. Men can work 12 hours a day at a pinch without much trouble; but how long can they remain vigilant—doing nothing? Still, with maintenance engineers doing the only real work, maybe they won't need the rest of us. What is more, when labour represents a trivial percentage of total costs, wages can be doubled without seriously affecting company profits.

It reminds me of the inquiry that was carried out into the industriousness of research workers in the Civil Service. A form was sent round to be completed in which the recipient was expected to indicate his activities through each working period during the day. One entire department wrote "thinking, thinking, thinking," etc., for the whole week. Nothing more was heard of the inquiry. Incidentally, I have it on the best sociological authority that most people would rather work for a machine than for a man any day.

CAPRICORN

Weekly Survey

Mechanised Fishing

A new and promising development took place in the world fish catching community when 75 representatives from 18 countries (including the United Kingdom, the United States and Western Germany but not Iceland, Soviet Russia or China) took part in the first Technical Meeting on Fishery Cooperatives. It was convened by the Food and Agriculture Organisation (FAO) and the International Labour Organisation ILO) and was held in Naples recently. Among the recommendations made was the development of fishermen's cooperatives, a prospect that might lead to increased mechanisation of the fishing industry, and give further scope for engineering ingenuity.

Delegates heard some plain speaking by Mr. Jervolino, Italian Minister of Merchant Marine. He said that fishermen must organise themselves into cooperatives in order to increase their technical and financial means, must adopt new systems to harvest the biological resources of the sea, and must rationalise their activities, reduce costs and increase their competitive position in the fish market. Mr. Jervolino told the conference that "it should make clear the moral, technical, economic and social advantages of fishery cooperatives." He pointed out that although most of the delegates had clearly similar interests in the development of fishermen's cooperatives, "few among you have ever acted before." He could see no other way of solving the difficult and pressing problems which confront producers and consumers. It is likely that in working together towards a solution they will be able to help fishermen in less developed countries who are confronted with the urgent task of developing their fisheries.

Like the Russian scientist who observed the tremendous difference between the rate of development of the whale and the elephant and concluded that sea food must be very fine, Mr. Jervolino obviously believes that food from the sea, efficiently harvested, could solve many of the world's developing nutrition problems. The chairman of the meeting, Mr. Malfettani, who is secretary-general of the Italian Cooperative Confederation (CCI) expressed the hope that governments will increase their support to the cooperatives without endangering their autonomy and independence. There is little doubt that a great deal is to be done to achieve even moderate efficiency and that governments have a heavy responsibility (and interest) in this new move towards unity in the fishing world.

Small Firm Finance

The encouragement of small business is the policy of the United States Government and the steps by which this may be carried out are embodied in the Small Business Investment Act of 1958. The stated purpose of the SBIA is "to stimulate and supplement the flow of private equity capital and long-term loan funds which small business concerns need for their growth, expansion and modernisation . . ." It is born of the realisation that lack of funds to carry a new scientific discovery into production stage often hampers the technically based small company. The Act will embody suitable restrictions but qualified companies "in any field of endeavour that promises growth" should benefit under the new programme now getting under way.

Several studies, including a recent report by the Federal Reserve Board, have shown there is a gap in the country's financial structure; there are really comparatively few organised sources of long-term capital financing generally available to small business. The Act proposes to close this gap by authorising the formation of small business investment companies and offering them various incentives toward providing long-term financing. Ten or more persons, supplying a minimum private capital of $150,000, may apply to form a SBIC, and thereafter for substantial Government support and for several privileges including special tax treatment. The SBIC's will be expected to provide capital to small businesses either by purchasing their convertible debentures or by making long-term loans. SBIC profits may come from interest earned on debentures and loans, dividends on stock holdings, and from conversion of debentures and sale of stock. Since some 99 per cent of the 4 million business firms in the United States are "small" by the official definition, the SBIC will have ample scope for their activities. The Act provides with considerably greater freedom for private enterprise in the provision of risk capital, for the type of assistance which has been offered by our own Industrial and Commercial Finance Corporation, and, less directly, by the National Research Development Corporation for the past decade. It is encouraging evidence that even in the United States the large companies have no monopoly of original ideas and scientific achievement.

Putting Bankers in the Picture

The promptness with which the bankers of the International Finance Corporation appointed an "engineer adviser" when the IFC was first organised in 1956, was taken as a theme by Dr. W. J. Jenkins at a recent regional meeting of the Industrial Association of Wales and Monmouthshire. Dr. Jenkins was formerly chairman of ICI (Nobel Division) and spent two years in Washington as engineering adviser to the IFC. It will be recalled that the IFC is a young sister organisation to the World Bank and is concerned with encouraging private investment in underdeveloped areas.

Working for IFC means assessing ventures by rather different criteria than those used by the World Bank. The problem of assessing the market for products and their profitability is of paramount importance, especially as the fruits of investment by the IFC have to be eventually marketable. Engineer advisers have therefore tended to be engineers with commercial and managerial experience; and it is perhaps because these qualifications are thought to be found more frequently in combination in the United States that the corporation has often used the services of American engineers who have had consultancy, hence wide, experience rather than specialists in any particular branch of engineering.

Two points are worth noticing. First, the IFC is following a trend which can be seen elsewhere of using increasingly the advice of engineers who have escaped from their particular ivory tower. Second, although there is emphasis in this case on broad experience, the engineering aspect is not submerged. The IFC has not fallen into the trap of thinking that establishing profitable ventures is only a management problem once the money has been found. The engineer is expected to play a major part in assessing the profitability of a proposal and the technical appraisal is given considerable weight.

Underwriting on the Wall

The last two weeks have seen two important developments in the field of American overseas investment. A new World Development Cor-

poration which would sell $15,000 million worth of stock to the American public for investment overseas, has been proposed in Washington. The authors of the plan have stated that the new corporation would deal with governments and other official instrumentalities and would deal also with private ventures of a representative and sound character. It would aim as soon as possible to transfer undertakings and securities to local management or ownership.

The first loan was also announced by the European Investment Bank which was established in 1958. This is a loan of $20 million to the Southern Italy Development Fund and represents part of a total borrowing of $70 million, the balance consisting of issues of £30 million of bonds in the United States investment market and a loan of $20 million from the World Bank. The development fund was created by the Italian Government in 1950 to carry out a large programme of public works in Southern Italy and to provide credit and other assistance to promote the development of agriculture and industry in the south of the country. The two loans totalling $40 million will help to finance the Mercure thermal electric power project south of Naples and the Sincat and Celene petrochemical plants near Augusta. The loan from the World Bank brings the total World Bank lending for this programme to nearly $260 million.

The Mercure power project involves the construction of a 210,000 kW plant on the Mercure River which will operate on brown coal deposits at the site. Sincat (Sta. Catanese S.p.A.) has already erected a plant for the production of complex fertiliser with an output of 300,000 tons a year. The new loan will permit an increase in fertiliser capacity and will also enable the company to enter the petrochemical field with the production of ethylene and ethylene derivatives. The Celane company will purchase ethylene from Sincat for the production of 10,000 tons a year of polyethene, ethylene oxide and other ethylene derivatives.

Economic Outsider

History may yet say that the outstanding mistake made by this country in its foreign policy in the middle years of the 20th century was to underestimate the political and emotional force behind the creation of the European Economic Community. By insisting on the need for the economic integration of Western Europe by means of a Free Trade Area this country has succeeded in excluding itself, at least temporarily, from membership of the Community.

Assessing the dangers of exclusion from Western Europe and the concessions which may have to be made involves a good deal of thinking and the preparation of public opinion. Public discussion can be helped by such organisations as Europe House which is holding a number of discussions on Britain and European Economic Association over the next month.

China Potential

The economic development of China is rapidly gathering momentum. Progress in Szechwan, the country's most populous province, is reviewed in the latest issue of the *China Trade and Economic Newsletter*. Szechwan is still mainly an agricultural community but it has considerable natural resources. Known reserves include some 14,000 million tons of coal, over 200,000 million cubic metres of natural gas and oil reserves said to be greater than those of Canada. A most promising oilfield has been discovered at Nanchung. Plans have been made for the construction of nineteen hydroelectric stations embracing two of the Yangtze gorges, with a capacity to generate more than twelve times China's present output. There are also sizeable deposits of iron and manganese, lead, zinc, nickel, asbestos, sulphur, mercury and other minerals including uranium.

Transport is a limiting factor but a rail and road network is being built up which is designed to transform the Szechwan town of Chengtu into the communications centre of south-west China, as Lanchow is of the north-west.

The development of the province should offer opportunities for Britain's engineering industries. There are also irrigation schemes which so far have increased the irrigated area from 1·8 million acres in 1949 to 6·3 million acres in 1957. Grain production rose from 19 million tons in 1955 to 45 million tons last year and is expected to reach over 67 million tons this year. Considerable efforts to expand the production of other crops and of livestock will create a large demand for farm machinery some of which may be imported.

Three Indian Steelworks

India is now part-way through the second of its two five-year plans. Part of this operation is to increase the output of steel to 6 million ingot tons a year by 1960-61, compared with 2·5 million tons in 1957. The main drive towards this target is the construction of three new iron and steel works, the contracts for which have gone to British, Russian and German firms. Britain is building the Durgapur works, Russia the Bhilai plant and Germany the Rourkela plant. All three belong to the state-owned Hindostan Steel concern.

Among the German firms taking part in the Rourkela project are Demag, Gutehoffnungshuette, Phillipp Holzmann, Friedrich Krupp, Lurgi GmbH, Mannesmann, Rheinstahl Union Brueckenbau, Schloemann, Siemag and Siemens-Schuckertwerke. The foundations at Rourkela were prepared by the Indian firm of Uttam Singh Dugal and Company, of New Delhi. The German contractors were full of praise for the work done by this firm and it is interesting to note that its engineers and workers have been trained by British staff.

American Bridgeheads in Europe

American investments in the Common Market and in the United Kingdom have both been under investigation recently. A table illustrating an article in *The Times* by Mr. J. H. Dunning, the author of *American Investment in British Manufacturing Industry*, shows that in 1957 Britain received a total of $1,899,000 in direct and portfolio investment. The nearest approaches to this were Germany with $496,000 and France with $457,000. The all-Europe total excluding the United Kingdom was $2,094,000.

At the present time the effects of opening the Common Market have barely begun to take effect. This certainly was the view of the delegation of United States stock market analysts who toured the financial capitals of Europe recently. Nevertheless, the number of American firms taking an interest in the Six nation area is increasing all the time. Here are some of the developments which have been reported in the past few weeks.

In Germany Smith-Corona (office equipment) have bought control of Hamann Rechnenmaschinen of Berlin. The Container Corporation of America has set up a subsidiary, Europa Carton AG at Hamburg. In France, Chrysler has purchased one-quarter of the capital of Simca and is planning to sell 60,000 Simca cars in America this year. The same firm has bought Kaiser-Fraser's factories in Holland.

Another development in France is the setting up of a consortium for nuclear engineering called Fromatone as the result of an agreement between Westinghouse Electric International and a number of steel firms including Jeumont and Creusot. The decision to build a tyre factory by Goodyear, and the launching of a subsidiary to make motor car spare parts by Budd are other recent moves. In Belgium both Proctor and Gamble and du Pont are building new factories in the Malines area. Du Pont are also planning a factory in Holland. These are only some of the places where American industry has moved into Europe. In the long run the answer may be that both Britain and the Six will benefit from the big expansion that is forecast in American national income over the next thirty years. Right now it looks as though the Six are getting the best of the New World in every sense.

Second Thoughts in Pakistan

At the present time over 95 per cent of steel production in the Far East is accounted for by Japan, China and India. The rest of the countries in the region, including Pakistan, Thailand, Burma, Malaya, Korea and Indonesia produce barely 1 million tons between them and have a very low consumption of steel per head of population. Nevertheless one of the forms that national ambition takes in newly-independent countries is the desire for steel mills. A very good example of this tendency is provided by Pakistan.

The plan for a steel mill at Multan was first put forward over four years ago. The plan was approved by the Government last year but is now under review by the new Government. The present policy is to emphasise agricultural rather than industrial development as the great need of Pakistan. The steel mill was expected to cost Rs 150 million, mostly in foreign currency. It was to be based on Kalabagh ore which is claimed to have an iron content of about 33 per cent. The plan put up by Krupps of Essen and approved by the Pakistan Industrial Development Corporation would, it is now stated, not have produced ore at an economic price. Ore with higher iron content has been found in Baluchistan but the size of the reserves has not yet been proved. The supporters of the steel mill plan point to the three new mills now being built in India. The Finance Minister however argues that steel produced at anything but an economic price is a luxury beyond Pakistan's present means.

The position now is that an American expert has been invited to Karachi to report on the plan. With regional, political and financial interests to consider, his assignment will be no sinecure.

Engineering Counterpoint

As the year proceeds, the recovery in the steel industry is becoming slightly more apparent, while the engineering industry is still, on the whole, waiting for better times. One sign of confidence in the steel industry is the higher level of scrap purchases which steel companies have been making in the last few weeks.

On looking more closely for signs of improved business, it is seen that recovery is exceedingly patchy. Large Russian orders for tubes and pipes, aided by some North American buying of structural steel, are the main favourable features in these sections of the steel industry. In the home market there has been a larger flow of inquiries but the stimulus from the Budget and any benefit there may be to derive from the higher level of consumer expenditure during the winter have both still to make themselves felt. Some of the alloy steels are doing better, but steel for railway equipment is a poor market. Overall, however, the industry is more confident than it was in the latter months of last year.

A recent quarterly business report of the Economic Survey Committee of the Purchasing Officers Association records that in the first quarter of this year order books in most sections of the engineering industry were continuing to fall. The extent of the decline was from 5 to 20 per cent. Some sections of the light engineering industry have reported substantial falls but business in the electronics section has been well maintained.

SEAWORTHY REACTOR

Vickers Nuclear Engineering present the case for a Steam-Cooled Heavy-Water Moderated Nuclear Power Plant—a system designed intrinsically for ship propulsion

Strong arguments are put forward in this article for and against the eight nuclear reactor systems submitted to the Galbraith Committee as bases for marine propulsion plants. (See The Eight Contending Nuclear Ships, ENGINEERING, 15 May '59, p. 638; also 22 May, p. 673.) Vickers Nuclear Engineering Limited, who have proposed a novel design using a steam-cooled heavy-water moderated reactor, point out that of the eight designs submitted, four were based on American technology and three on the traditional Atomic Energy Authority gas cooling and graphite moderation, a combination, the author argues, completely unsuitable for seagoing application. The Vickers system, which is the eighth, is said to be " the only original and true blue marine design." The author writes that he is indebted to Dr. S. G. Bauer and Rolls-Royce Limited for the reactor design, to Foster Wheeler Limited for details of the primary steam circuit, and to Vickers Limited for permission to publish the article; the three companies being joint members of Vickers Nuclear Engineering Limited. Any opinions expressed are his own. A second article will consider the technical features of the Vickers design in greater detail.

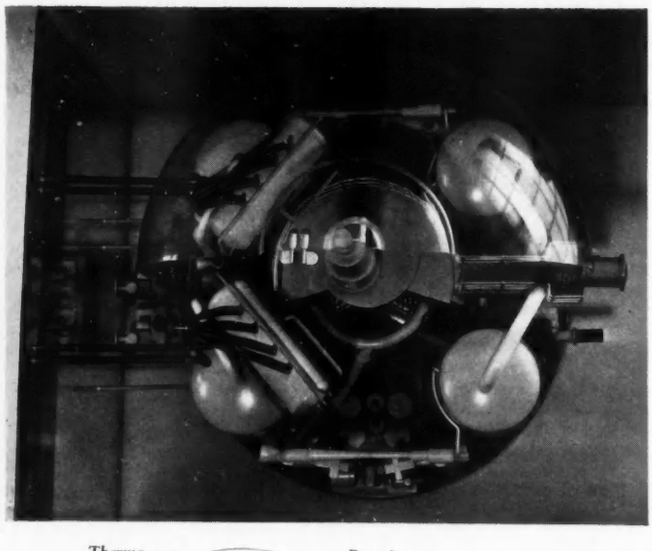


Fig. 1 Model of the steam-cooled heavy-water moderated reactor, with associated plant, designed by Vickers Nuclear Engineering for propulsion of a merchant ship.

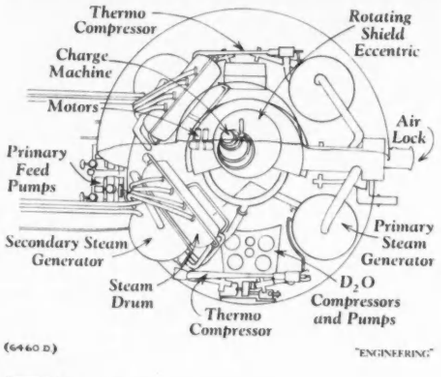
By Captain H. F. Atkins
D.S.O., D.S.C., R.N., M.I.Mech.E., M.I.Mar.E.
of Vickers Nuclear Engineering Limited

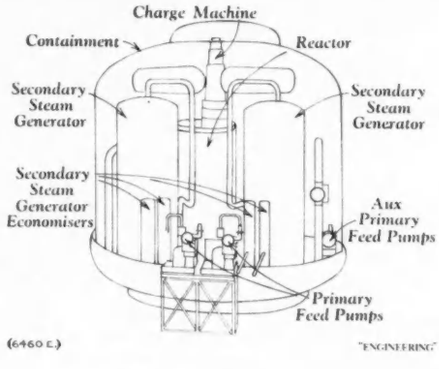
Choosing a Marine Reactor

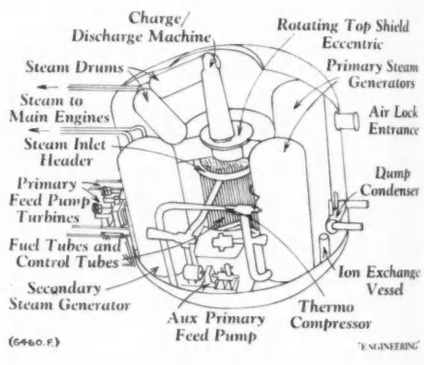
A NUCLEAR reactor for a merchant ship must be highly reliable, very flexible in operation, and capable of development into an economically competitive source of power. The last consideration and the desire not to be dependent on the United States explains why Vickers Nuclear Engineering are not putting forward the pressurised-water reactor for merchant ship propulsion as their first choice.

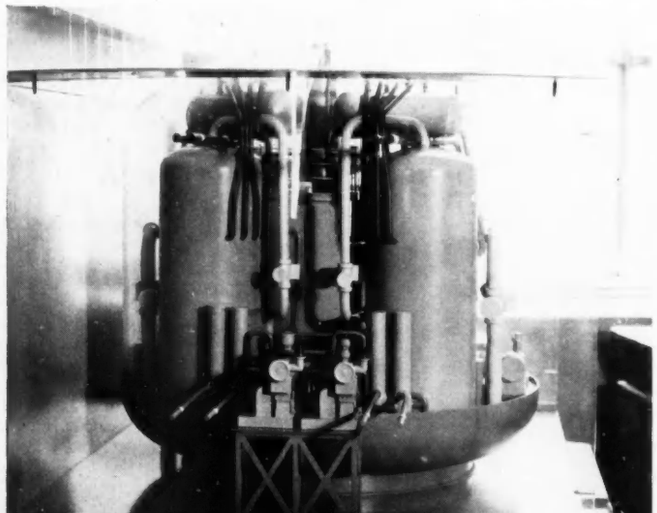
Pressurised-Water Reactor

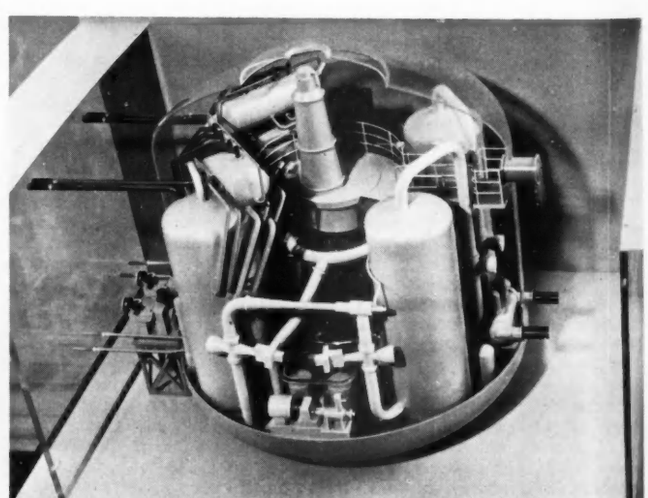
The pressurised-water reactor, though reliable, is uneconomic because of the high enrichment it needs and its low water outlet temperature necessary to avoid boiling, which inevitably results in low thermal efficiency. Even with











plutonium enrichment both these factors will still handicap the PWR *vis-a-vis* nuclear reactors of better neutron economy and higher thermal efficiency. The PWR has already reached its limit of development unless boiling is allowed, but it is, of course, the only type now at sea.

Boiling-Water Reactor

The boiling-water reactor also requires considerable enrichment and is capable of giving only saturated steam unless a separate superheater or superheating section is fitted. The reactor acts as a concentrator of solids from the feed water, just as any other boiler does. Blowdown of the radioactive solids by remote control will be extremely tricky. The reactivity of the reactor depends on the maintenance of the correct water level, which must be effected entirely by remote control; so that control of the reactor would seem to a marine engineer to be highly hazardous, particularly as the forcing rates and steam release in BWR designs are high, even in comparison with those used in naval boilers. It is said that the trouble with change of reactivity due to steam voids has been overcome on shore, but it is by no means certain that the same will be true in a ship in a rough sea. A direct cycle in which the feed to the BWR comes from a salt-water cooled condenser will put sea salts straight into the reactor when a leak occurs, and their corrosive effects will be disastrous.

Graphite

In oil burning steamships, the boiler brickwork needs the most frequent repair of any part of the whole machinery. Water walls have reduced this upkeep but the marine engineer would be delighted to dispense entirely with refractories. Their reintroduction in the form of a graphite core would put the clock right back. The PIPPA pile, made up of long narrow pillars of graphite bricks and tiles, would not remain standing long in a rough sea. Details of the seagoing version of the Advanced Gas Cooled Reactor (AGR) are not available, but if the pile is properly supported the decreased neutron economy and increased enrichment mean that its fuel costs will be much the same as the light-water and organic moderated reactors. The AGR, designed for the Galbraith Committee, appears to be bursting out of the hull, and the overall weight is twice that of some other projects. The author profoundly hopes that after the time and money spent on this abortive effort, the United Kingdom Atomic Energy Authority will finally abandon trying to make this type of reactor seaworthy.

Organic Liquid Moderated Reactor

The organic liquid moderated reactor has the attraction of simple low-pressure plumbing. The search for a suitable hydrocarbon has gone on for so long that it seems unlikely that anything much better than terphenyl will be found. The coolant temperature it allows is not high enough to give a reasonable thermal efficiency, the enrichment needed is high, the thermal efficiency low and the development potential invisible. It is stated that there is no deposition of carbon on the reactor heating surfaces, even when polymerisation and gas release takes place. This contention seems highly unlikely judging from the behaviour of other hydrocarbons and requires a lengthy trial under seagoing conditions, as once any such deposit forms, from the cracking of the coolant, the hot spot will rapidly build up carbon with diastrous effects. Coolant leaks are said to be immaterial as so little radioactivity is acquired, but the smell of hot terphenyl is utterly nauseating.

Gas cooling

For economy with gas cooling, high thermal efficiency of the cycle and high neutron economy are needed. The reactor chosen must supply heat at the highest temperature at which it can be employed. The high-temperature gas-cooled reactor is expected to give a high enough temperature for a gas turbine as efficient as a good steam turbine. Gas turbines have made little headway at sea in fifteen years, save in fast coastal craft, as boost engines or auxiliaries. The "Auris" and "John Sargeant" are lone swallows. If gas is supplied to turbines directly from a reactor, radioactive leakage from turbine and compressor glands will add greatly to the many problems already found in adapting the gas turbine to the sea. Gas to steam heat exchangers are much bulkier than steam to steam ones and the supply of gas is an additional logistic problem. Gas cooling, therefore, seems to be completely unsuited to a ship.

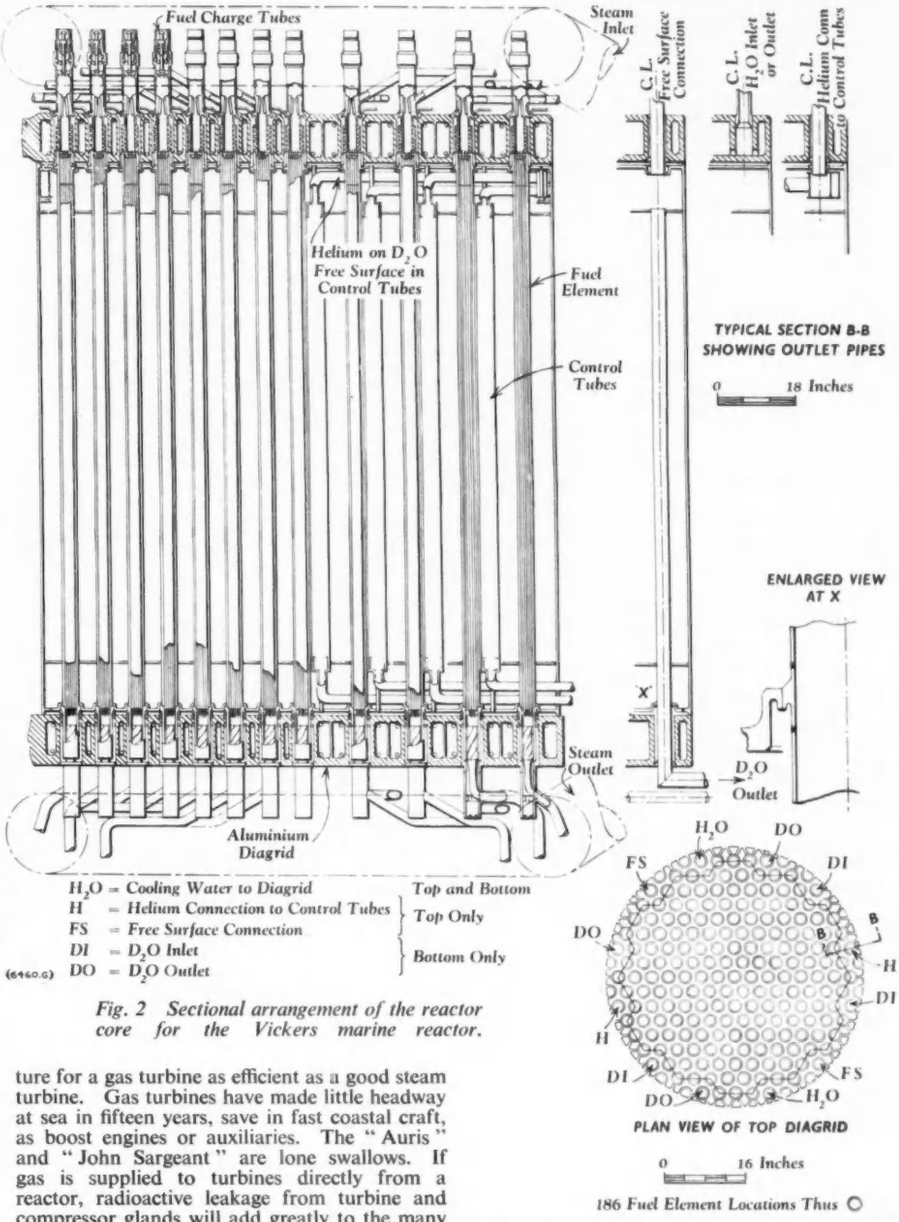

Fuel Charge Tubes
Steam Inlet
C.L. Free Surface Connection
C.L. H_2O Inlet or Outlet
C.L. Helium Conn to Control Tubes
Helium on D_2O Free Surface in Control Tubes
Fuel Element
Control Tubes
TYPICAL SECTION B-B SHOWING OUTLET PIPES
0 18 Inches
ENLARGED VIEW AT X
X
D_2O Outlet
Steam Outlet
Aluminium Diagrid
H_2O = Cooling Water to Diagrid — Top and Bottom
H = Helium Connection to Control Tubes — Top Only
FS = Free Surface Connection
DI = D_2O Inlet — Bottom Only
DO = D_2O Outlet
(6460.G)
PLAN VIEW OF TOP DIAGRID
0 16 Inches
186 Fuel Element Locations Thus ○

Fig. 2 Sectional arrangement of the reactor core for the Vickers marine reactor.

Vickers System

To overcome the various defects of the systems considered above, Vickers Nuclear Engineering have evolved a reactor system designed from the beginning as a marine plant. The Vickers system uses heavy water as moderator and steam as reactor coolant. Certain of the features described below refer only to a small prototype reactor, but there would be no difficulty in scaling up the system for higher powers. The arrangement of the reactor plant can be seen from the model illustrated with keys in Fig. 1. A part section of the reactor core appears in Fig. 2.

Steam Cooling

Steam cooling has the advantages that the steam can be supplied to the turbines at the temperature and pressure used by the most advanced steam turbines now at sea, and that it can be pumped as water, which reduces the circulating power required to a fraction. If it enters the reactor as dry steam the problems of deposition of solids in the reactor, so harrassing in the BWR, will not arise. Used thus, it is the ideal coolant for direct use in the main engines.

Heavy Water Moderation

To give high neutron economy, the moderator with the least absorption cross section, heavy water, is used; it is kept cool in order that its moderating properties remain the best possible and to keep it below its boiling point at atmospheric pressure so as to minimise the chance of its loss through leakage. With the best moderator the enrichment of fuel is minimised, the conversion ratio of uranium 238 to plutonium is increased and consequently a long life for the core with complete xenon override is obtained.

Control and Safety

The reactivity of the reactor is controlled by the addition or removal of the heavy-water moderator from selected parts of the reactor. This principle dispenses with control rods, which are a great disadvantage in a ship, since control rod mechanisms are intricate, delicate and vulnerable to jamming due to the movements of the ship, and in most reactors depend on gravity to fail safe.

The method of scramming the reactor is simple :

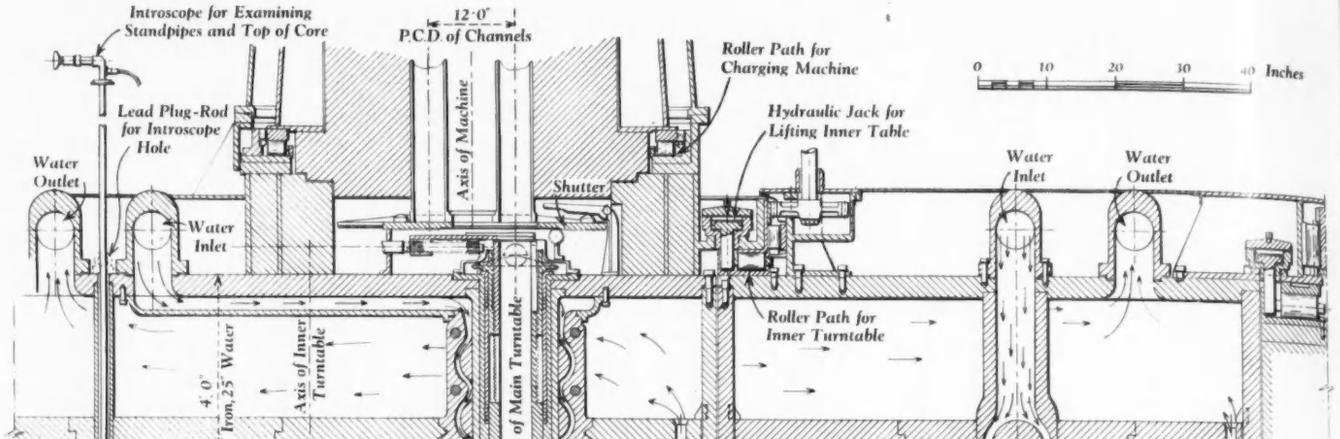

Introscope for Examining Standpipes and Top of Core
12·0" P.C.D. of Channels
Roller Path for Charging Machine
0 10 20 30 40 Inches
Lead Plug-Rod for Introscope Hole
Hydraulic Jack for Lifting Inner Table
Water Outlet
Axis of Machine
Shutter
Water Inlet
Water Inlet
Water Outlet
Roller Path for Inner Turntable
4·0" Consisting of 2" Iron, 2" Water
Axis of Inner Turntable
Axis of Main Turntable
28·845" Throw of Eccentric
34" to Top of Standpipes
4 Coils Operating 2 Galvanometers for Aligning Access Tube with Stand Pipe
(6460.1)
"ENGINEERING"

Fig. 3 Arrangement of the inner and outer turntables and water-cooled top shielding of the reactor, showing the means for aligning the charge-discharge machine with the fuel standpipes.

appropriate valves are opened to let the moderator run out of the control tubes under gravity. Tube connections both top and bottom and dump tanks are arranged so that, whatever the heel and trim of the ship, the moderator will run out of the core and not return. Reactor scram is automatic if the ship turns turtle as the top connecting pipes are always open.

In the Vickers design there are no shut-off rods, or in-reactor mechanical shut-down devices, which might fail to operate under these conditions.

TABLE.—*Plant Parameters for the VNE Steam Cooled Heavy Water Moderated Marine Reactor*

Output	
Reactor heat output	150 MW
Reactor Core	
Core diameter (nominal)	10 ft
Calandria tank inside diameter	10 ft 4 in
Core height (nominal)	10 ft
Calandria tank inside height	10 ft 8 in
Number of fuel channels	186
Lattice pitch	8 in (triangular)
Calandria tube	aluminium alloy 3⅛ in i.d. by ⅛ in thick
Fuel channel barrier tube	stainless steel 3·1 in i.d. by ·015 in thick
Number of moderator removal tubes	147
Moderator removal tube	aluminium 5·06 i.d. by ·030 in thick
Heat barrier gas	helium
Reflector	
Radial—D_2O (nominal)	2 in
H_2O	6 in
Axial—D_2O (nominal)	6 in
H_2O (combined with structure cooling)	nominal
Fuel	
Material	UO_2
Density	10 gm per cu. cm
U^{235} content	(approx. 1·7 per cent)
Number of fuel rods per element assembly	19
UO_2 pellet diameter	0·50 in
UO_2 pellet length	0·75 in
Canning material	stainless steel
Canning thickness	0·010 in
Active fuel rod length	10 ft
Weight of UO_2 per element assembly	73·4 kg (162 lb)
Total weight of UO_2	13·6 tonnes
Weight of fuel element assembly (including stand pipe plug)	200 lb
Fuel element max. surface temp.	680°C (1,256°F)
Fuel element max. centre temp.	1,700°C (3,100°F)
Moderator	
Type	Heavy water
Quantity in reactor tank (control tubes full)	50,000 lb
Quantity in external circuit	5,000 lb (estimated)
Heat production in moderator	10·5 MW
Moderator circulation rate	138 lb per sec
Moderator reactor inlet temp.	50°C (122°F)
Moderator reactor outlet temp.	90°C (194°F)
Reactor Cooling	
Coolant	steam (H_2O)
Mean steam pressure	600 lb per sq. in abs.
Pressure drop in coolant channel	20 lb per sq. in
Reactor total steam flow	1·74 by 10^6 lb per hour
Reactor coolant inlet temp.	260°C (500°F)
Reactor coolant outlet temp.	520°C (970°F)
Max. channel steam velocity	180 ft per sec

Primary Steam Circuit	
Circulators	2 thermocompressors
Thermocompressor nozzle steam	1,800 lb per sq. in abs. 650°F
Each thermocompressor nozzle steam flow	212,300 lb per hour
Each thermocompressor suction steam flow	657,820 lb per hour
Thermocompressor suction steam	570 lb per sq. in 496°F
Thermocompressor discharge steam	640 lb per sq. in abs. (approx.) 500°F
Feed pumps	two, 100 per cent Turbine driven
Auxiliary feed pumps (capacity 7 per cent approx.)	2, electrically driven
Steam flow to secondary steam generators	2, 212,300
Minimum feed water pressure (on feed pump suction)	525 lb per sq. in abs.
Live steam feed heaters	
Feed inlet temp.	340°F } normal
Feed outlet temp.	350°F }
Secondary Steam Circuit	
Secondary steam pressure	420 lb per sq. in abs.
Secondary steam temp.	850°F
Secondary steam flow	2, 212,400

Physics

Lattice constants for hot clean core, with enrichment of 1·7 per cent.

(1) *Moderator tubes full*		(2) *Moderator tubes empty*	
f	0·8576	f	0·8602
p	0·8723	p	0·7921
η	1·5963	η	1·5963
ϵ	1·0225	ϵ	1·0225
k_∞	1·2212	k_∞	1·1122
L^2 (Radial)	70·4538	L^2 (Radial)	107·7917
L^2 (Axial)	71·3502	L^2 (Axial)	144·5153
L_g^2 (Radial)	154·8433	L_g^2 (Radial)	445·8469
L_g^2 (Axial)	157·5439	L_g^2 (Axial)	577·1277
k eff	1·1345	k eff	0·9214

Initial conversion factor (average at start of life)	0·53
Average conversion factor (over core lifetime)	0·52
Axial form factor	1·48
Radial form factor (start of life)	1·17
Average thermal flux in the fuel	$2·12 \times 10^{13}$
Average thermal flux over all core materials	$4·19 \times 10^{13}$
Enrichment 1·7 per cent	
Reactor total heat output	
at (*a*) full main engine power	160·5 MW
(*b*) half main engine power	82·5 MW
Core lifetime in MWD's	
at (*a*) full main engine power	74,563 MWD
(*b*) half main engine power	76,656 MWD

Steam Circulation

Circulation is achieved by thermocompressors or steam injectors. The reactor superheats steam at 600 lb per sq. in from 500° F to 970°F. Part of the superheated steam goes to the secondary steam generators where it superheats and evaporates the steam for the main turbines (in the indirect cycle). It condenses and returns from a contact feed heater to the feed pump. The feed pump increases the pressure of the water to 2,100 lb per sq. in to supply the nozzle steam of the thermocompressors passing through the coils of a once-through boiler, in which it is evaporated by a supply of superheated steam from the reactor. The thermocompressor sucks the desuperheated steam from the shell of the once-through boiler and returns all steam to the reactor.

The steam cooling system is largely self-circulating, the only main mechanical auxiliary being the feed pumps. Under normal operation these are driven from turbines taking secondary steam, thus the system is almost independent of electrical power supplies. The only essential electrically driven auxiliaries are the moderator circulating pumps but failure of these produces a moderator mean temperature rise of less than 20° F in a minute under full power conditions.

Pressure Tube Construction

The heavy water is contained at atmospheric pressure and low temperature in an aluminium calandria and no reactor pressure vessel is needed. In a pressure tube design with individual coolant connections it is possible to scale the reactor up or down by adding or removing pressure tubes and one prototype may serve for a family of reactors of different output. It is also possible to check the lattice parameters by installing a small section of the reactor in an existing heavy-water moderated reactor. The design leads to production quantities in the most critical parts of the core. For ship work the lack of a pressure vessel has great advantages in reducing the maximum lift required. It is understood that for the AGR it would be necessary to weld the pressure vessel on board and stress relieve it in position—a most difficult task for the shipbuilder. Arrangements for fuel charging may be gathered from Fig. 3, which shows the means of aligning the charge-discharge machine with a particular fuel channel, the inner and outer turntables, and the water-cooled top shielding.

Materials

As the reactor is designed for immediate construction only existing technologies and

well-known materials are used. It is very desirable that none of the materials of construction should be capable of chemical reaction with another or with sea water; the combination of uranium dioxide, stainless steel, aluminium and water seems as good a choice as can be made in this respect. Outside this shield ordinary boiler steels are used.

Logistics

With a steam-coolant plant, the inevitable coolant losses can be made up from the ship's evaporators, double-distilling sea water and passing it through the ion exchangers. The heavy water and helium losses are not expected to be large enough to constitute a supply problem. Indeed, the circuits containing them must be so designed and the welding and testing so careful that the leaks are negligible, and keep down the costs of make-up. The heavy-water circulating pumps have no glands and the control and scram valves can also be glandless. The only logistic restriction to the ship's movements will be food supply for her crew and the need to dock the hull for scraping and painting. The core lifetime can be made virtually as long as is desired.

Containment

Under severe accident conditions involving the release of primary coolant into the compartment, such as the fracture of a pipe, the use of steam has two fundamental advantages. The first is that the containment pressure is only transient as sooner or later the steam will condense. The second is that this condensation removes heat from the fluid in the containment during the release of coolant, thus reducing the maximum pressure attained.

The containment has been designed to contain all the primary coolant under the worst accident conditions. This involves a rapid release of the steam at 600 lb per sq. in followed by a slower release (through the thermocompressor nozzles) of the fluid at 1,800 lb per sq. in and the flashing hot feed water. Any other accident would involve a slower release of the primary fluid into the containment where condensation will have a greater effect. Simultaneous rapid release of primary fluid under the worst accident conditions and secondary fluid is not considered a credible accident. There is no doubt that design development, particularly on heat exchangers, can greatly reduce the quantity of primary steam at 600 lb per sq. in and thus bring down the greatest containment pressure.

The only significant amount of inflammable material within the containment is the lubricating oil for the feed pump bearings, thus fire within the containment is not considered a significant hazard.

Development Potential

More work on this study will lead to many savings in cost, weight and size of the plant. Experiment will allow many of the margins assumed in the study to be trimmed. When the fuel elements have been proved reliable, a direct cycle, passing steam from the reactor directly to the main engines, will be used. This will result in better steam conditions and substantially constant temperature and pressure at the manoeuvring valves. The control of the plant will be simpler and feed pump power, as well as much piping complication, and the secondary heat exchangers, will be saved.

Alternatively, the plant could be operated at half to full power on open cycle and at less than half power through an intermediate heat exchanger. Thus, the advantages of higher plant efficiency and better steam conditions would be available at the larger powers where they matter, and half power would be available without radioactivity hazards in case excessive activity were released in the primary circuit. There would be substantial saving in heat exchangers. The self-pumping circulating system development in this study is attractive for safety as well as from the thermodynamic and mechanical angle. It might be applied with success to a different type of core from the one here described. The economic advantages of heavy water as a moderator decrease with decreasing size of reactor and it is quite likely that for lower outputs the light water moderated reactor with the same type of circuit may show to advantage.

There are several possibilities of increasing the rating of the plant, and conversely, reducing its size. The fuel element rating is conservative and either the maximum channel output or the outlet temperature or both might be raised. Injection of feed water as spray or mist into the inlet of each fuel channel would give a substantial increase of output for the same surface and outlet temperatures and at the same time reduce very substantially the duty of the primary steam generators. This improvement is possible by adaptation rather than by redesign.

As about half the volume of the primary steam generator serves as feed heater, it would seem attractive to use, say, the outer portion of the reactors for water heating and the inner portion for steam heating. The water heating section could be made in Zircaloy and thus further save in enrichment or provide both flattening and a longer reactivity life. The saving in heat exchangers would be set off against considerable extra complications in the core and piping.

The usual life of a fuel charge for the reactor as proposed is three years with full xenon override or five years without. If the economic life of the ship is twenty years it would not seem impossible to design a core with fuel elements which would last for the life of the ship. It would mean a higher initial enrichment and burnable poisons against large saving in reprocessing and fabrication costs. Although this step seems feasible from the physics angle, it is a very long extrapolation of practical experience at the present stage of the art and it is difficult to face the thought of relying on a fuel element for twenty years without touching it.

The use of beryllium in this reactor is worth considering. Beryllium, resistant to high temperature steam, is not a commercial possibility today though there is no reason why it should not be developed. A big improvement would result from the use of a beryllium barrier tube instead of a stainless steel one; the initial enrichment could be reduced from 1·7 to about 1·4 per cent. Since the neutron absorption is negligible, the tube could readily be made thick enough to take the full pressure stress on short-term strength in case of accidental loss of balanced pressure.

The outstanding problems are corrosion resistance or protection, joining to stainless steel at the ends, and the additional temperature coefficient effects on reactivity. Beryllium canning must stand 700° C instead of 520° C for the barrier tube. A complete beryllium channel would bring the initial uranium 235 concentration down from 1·7 to about 1·2 per cent.

The steam circuit and the mechanical design of the reactor will be considered in a further article.

Notes and News

Atomic Review

Atomic Power Constructions win Trawsfynydd

The Central Electricity Generating Board have issued a letter of intent to enter into contract for the building of a 500 MW nuclear power station at Trawsfynydd, Merionethshire, with Atomic Power Constructions Limited. The company, which also has a project team working on a tentative station for Dungeness, has been building up its research laboratories at Heston. The permanent laboratory executives appointed at Heston are: Mr. H. E. Dixon (head of research and development) and Dr. A. G. H. Coombs (deputy head of laboratories). A drawing of a proposed APC nuclear power station appeared in Atomic Review last 28 March.

Savannah to be stabilised

Stabilisers are to be fitted to the nuclear ship Savannah now that additional funds have been granted.

Fission Reactor Work at AWRE

Beryllium and plutonium are two materials of fission reactor interest being studied at the Atomic Weapons Research Establishment.

Beryllium is a metal which has sprung into prominence in recent years, both in the nuclear field (because of its low absorption cross-section for neutrons, its high moderating efficiency and its high melting point of 1,290° C) and also in the structural engineering field (due to its low density, its high strength to weight ratio, and its mechanical stiffness). At AWRE work has included technology as well as fundamental research, and the advances made include the following. (1) A sintering method has been developed requiring no application of pressure at any stage in the process. It significantly cheapens the consolidation processes that are used in conventional powder techniques when producing simple shapes. (2) A novel cold-pressing technique has been devised that enables complex shapes to be produced from beryllium powder. This method again cheapens conventional techniques by cutting down the machining required. (3) Techniques for welding beryllium end caps for use in high-temperature reactors have been developed. A new vacuum high-intensity electron-beam technique is employed in the process. Finally (4) processes to improve the high temperature properties of the metal have been evolved. In fundamental research, work has been concentrated on the purification of beryllium by high-temperature vacuum distillation and by zone refining, in an attempt to improve the ductility. A significant outcome of this work has been the discovery of a high-temperature transformation in the crystal structure of beryllium—a development that may well effect the future use of cast beryllium.

Plutonium fuel elements are so important to the British nuclear power programme that means should be discovered of using plutonium in thermal reactors. Basic experiments to this end are being carried out at Harwell; the AWRE contribution is to fabricate fuel elements containing plutonium for use in these tests. The element consists of a strip of plutonium-aluminium alloy, contained within a thin aluminium sheath. The element contains 20 per cent by weight of plutonium. After being cast, the alloy is rolled to the correct thickness and then cut to size. This core is inserted in the sheath, which is then sealed by welding. Because of the great toxicity of plutonium, all these operations have to be carried out in glove boxes. Over 500 of these have now been made here and delivered to Harwell; some are under test in GLEEP. Later, elements will be tested in DIDO as a unit. Plutonium oxide elements are known to have been tested in the United States and USSR, but the AWRE elements use metallic plutonium.

Fusion Controlled and Uncontrolled at AWRE

As reported in these columns (most recently on 29 May), AWRE have been working on fast pinch thermonuclear machines, probably from now on of torus design; but in addition the establishment has undertaken theoretical studies of the application of nuclear explosions to earth moving, as in the excavation of harbours and the liberation of oil from shale. The studies have been limited to attempts to determine the sort of cavity a bomb will create. The theoretical problems are considerable, for example, it is shown that the strength of the earth's trust varies with the rate of strain. (See Atomic Review 13 February '59 and 28 March '58.)

Companies in the News

Simca Challenges Citroen

The youngest of the big four of the French motor car industry, Simca, will celebrate its 25th birthday later this year. Last year Simca built 206,751 cars, an increase of some 30,000 over the previous year. Even so it is still running number three after Renault and Citroen and just in front of Peugeot. Renault's output of about 412,000 is far ahead of the other three. The indications are that Simca will be battling with Citroen for second place in the next few years.

The main reasons for this are new plant and new distribution arrangements. The new factory at Poissy near Paris was opened during the year. It is considered to be one of the most up-to-date plants in Western Europe. The buildings housing the assembly lines for the Aronde, Ariane and Vedette are already complete. The second big development by Simca last year was the signing of an agreement with the Chrysler Corporation under which the corporation will handle distribution in the United States and Canada.

At the Simca annual general meeting in Paris M. Pigozzi the chairman said that a strong home market was essential to the development of export sales. He went on to say that he hoped that the authorities would take steps to place the French motor industry in a position similar to that of its European competitors. These two statements taken together would seem to imply that any move to increase quotas of car imports into France from countries outside the Common Market would be most unwelcome.

Pumping Head

The results of two of the country's leading pump manufacturers, G. & J. Weir Holdings Limited and Worthington-Simpson Limited, are much better than might have been expected. Those of a third, the Pulsometer Engineering Company, are not; but in their case special factors contributed to a drop in profits from £484,000 to £406,000. Their chairman, Mr. F. B. Duncan, told shareholders that considerable additional expenditure was involved in replanning and modernisation.

G. & J. Weir's trading profits before tax were up by approximately £250,000 to £2·99 million. Their chairman, the Hon. J. Kenneth Weir, indicated that the improvement resulted from an increase in output " made possible by the strong order book position built up during the latter part of 1956 and during the first nine months of 1957." During the last quarter of 1957, and during the whole of last year orders for new work fell sharply and price margins were reduced. Despite this there is still plenty of work available for 1959.

The trading profits of Worthington-Simpson were up slightly, to £1·15 million. But their chairman, Sir Samuel R. Beale, does not expect them to be maintained in 1959. Recent " peak results " were affected by long term contracts for heavy electrical plant. Less is now available, although the company have on their books a £2 million contract to equip a power station at Buenos Aires.

Oil Pressure on Prices

The results of two of the leading oil companies, the British Petroleum Company and the Shell Transport and Trading Company, show that the recession has had little impact on their profits. BP's trading profits increased from £113·9 million in 1957 to £123·8 million last year, and those of Shell Transport and Trading from £17·7 million to £18·4 million. In his report to shareholders BP's chairman, Sir Neville Gass, draws attention to the economic difficulties which have arisen and suggests that the full impact of the recession may take place during the current year. 1959, he said, began in difficult market conditions and early in the year there was a world-wide recession in crude oil prices, which followed a progressive weakening of these prices in the United States during the later months of 1958, reflecting the pressure of lower product prices on already narrowed refiners' margins. To continuing pressure of this nature was added one arising from plentiful supplies, to which important new discoveries in Venezuela contributed. The price weakness extended to the Middle East crude oil market, and led in February to a general reduction in Persian Gulf and East Mediterranean crude oil prices.

Sir Neville Gass's view of current prospects is therefore a cautious one. " There are," he said, " factors militating against an early improvement in trading conditions. Demand though increasing has not caught up with supply, more oil is coming on the market from newly developed areas such as the Sahara and from Russian sources, and limitation of imports into the United States may cause other markets to be sought for oil discovered in Venezuela. . ." Lord Godber, chairman of Shell Transport and Trading, took a somewhat more cheerful view. He pointed out that the general economic outlook at the beginning of this year appeared more favourable than it did in 1958, though in Europe signs of expansion are not yet very marked and the primary producing countries are still suffering from low commodity prices.

More Titanium Oxide

British Titan Products Company have just completed a major extension to their titanium pigment producing plant at Grimsby. Construction has taken two and a half years and has cost over £2 million. This brings the company's annual capacity at Grimsby to 70,000 tons, mainly of rutile grades which supplement the production of anatase grades at this company's plant at Billingham-on-Tees.

The Human Element

Automated People

The dangers of basing national policies for automation on myths for want of systematic study of its impact on society is an issue raised by Mr. John Diebold in a recent report called *Automation: its Impact on Business and Labour*. Mr. Diebold has been for some time an advocate of the realistic as opposed to the glamorous approach to automation and he returns to this theme in his report. The report is published by the National Planning Association in the USA.

He stresses that in his opinion automation in the near future is going to bring a revolution in the office rather than in the factory. He thinks that a revolution is in any case overdue in that direction. This will give rise to displacement of labour and " de-skilling " of operatives. Some will get more skilled jobs, some less highly paid jobs and in certain cases, whole communities will be affected, as the question of location of industry is influenced by automation techniques applied to factories and offices. One of the big problems he sees involves finding the people to train workers of all types for the kinds of job which will be available in an automation age. He is also concerned about the use of leisure in an age which has reached a very high standard of living, thanks to automatic techniques.

Esprit de Copywriter

Not many concerns bother to introduce their employees to their advertising campaigns. Not very many would see why they should. The Projectile and Engineering Company has tried their hand at it in an attractive leaflet, which has been distributed with the wage packet. The idea of telling employees on the shop floor why products are advertised in a certain way and how a particular campaign came to be conceived could form part of a general scheme for keeping workers informed about the company's activities, contributing to improved *esprit de corps*.

If schemes of this kind are to take root in industry they will need much careful thought. Factory operatives do not live in a world where copywriters' wit has a ready currency or where the advertising agency's bright, and at times, brittle, attitude to the company's products finds a sympathetic ear. Nevertheless, the Projectile and Engineering Company have made an interesting innovation, and few, when they are away from the workshop, will be able to resist a faint boast of recognition when they see Pete Peco in some prominent position.

Youth Springs Eternal

The search for the " elixir of youth " is fast becoming a respectable research assignment. In the words of the medical correspondent of *The Times* " in these latter days, with the increasing expectation of life, the search has assumed academic status—and corresponding respectability." The basic theory upon which scientists are working has its roots in the transformation of the larvae of the blood-sucking insect Rhodinus, and dates back about 25 years. A research scientist, Dr. V. B. Wigglesworth, found that the decapitation of the larvae resulted in a prompt metamorphosis into miniature adult insects. He advanced the hypothesis that this rapid metamorphosis was due to the removal of a " juvenile hormone " which was secreted by the corpora allatta, a small cluster of cells immediately behind the brain. Subsequent work has fully confirmed Dr. Wigglesworth's hypothesis. An American scientist working at Harvard University, Professor Carroll M. Williams, has carried out extensive research into the juvenile hormone and has concluded that " most, and perhaps all, mammallian tissues contain demonstrable amounts of a substance the biological activity of which in the insect assay is indistinguishable from that of the juvenile hormone." The next step may well be to concentrate upon the discovery of the chemical nature of the hormone.

In this country research has been proceeding from a different angle. In a lecture to the Royal Society, Dr. M. F. Perutz, F.R.S., who is director of the Medical Research Council Unit for Molecular Biology, said that he expected the simplest forms of life to be understood in molecular terms within the next twenty years. " The key problems are the structure of the nucleic acids, on which genetic replication and protein synthesis depend, and the structure of the protein catalysts which control metabolic activity." Understanding on these planes would open up vast possibilities and raise social problems which would surely defy man's ability to order life on earth.

Frozen Human Energy

The contention that management has lost control of the rewards and punishments that determine the satisfaction of workers at all levels has recently been put forward by Professor Fritz Roethlisberger. He has been awarded the Ledlie Prize which is the top faculty honour of Harvard University. He talked of " the vast amount of frozen human energy that exists in our modern organisations," and argued that management must assume a new role of leadership in " freezing the creative impulses of workers in organisational settings."

The Ledlie award, established by the late George Ledlie, newspaper executive and associate of Joseph Pulitzer, is given every two years (this was the third award) to the individual at Harvard who has " by research discovered or otherwise made the most valuable contribution to science, or in any way for the benefit of mankind."

SOVIET IRON AND STEEL INDUSTRY

Destruction, Recovery and Achievements

Russia is now the second largest iron and steel producer in the world, but in 1913 she held the fourth place among the iron and steel producing countries.

During the First World War the Russian output figures dropped progressively, and in the ensuing civil war the industry was practically at a standstill. It was not until 1930 that the pre-war production level in iron and steel was reached again.

At that time Soviet industry was already half way through the first Five Year Plan. With considerable help from abroad, 41 new blast furnaces, 65 open hearth furnaces and 32 rolling mills were put into operation during this period (1928-32). Many existing works were greatly expanded. The plan also involved the construction of a number of alloy steelworks and the expansion of the capacity of coke-ovens.

But the big and rapid expansion programme of the first Five Year Plan failed to yield the expected results. The new hurriedly erected plants, operated by inexperienced engineers and unskilled workers, and suffering from shortages in almost every field, were unable to make all that was expected, either in the required quantity, quality and variety.

During the second Five Year Plan (1933-38) less basic production capacity was installed than in the preceding period, but the output of the industry rose considerably because of the ironing-out of the disproportions and the removal of the bottlenecks created in the first five year period.

WAR DESTRUCTION MADE GOOD

A very considerable proportion of the productive capacity of the Russian iron and steel industry was destroyed during the first months of the Second World War so as not to allow it to fall into the hands of the Germans. Only a few of these were made good by the 10 blast furnaces, 29 open hearth furnaces, 16 electric furnaces, and 15 rolling mills installed during the war in various parts of Siberia and Central Asia. Much of this equipment was, of course, supplied by Russia's war-time allies.

The reconstruction of the very thoroughly destroyed plants had already begun during the German occupation and was continued very rapidly after the liberation. In 1950 the Soviet ferrous metals industry exceeded its pre-war production rates in pig iron by 29 per cent and in steel and rolled products by 49 and 59 per cent respectively. The increase in output continued and in 1957 reached 37 million tons of pig iron, 51·0 million tons of steel and 40·2 million tons of rolled steel.

The iron and steel industry, as well as the heavy engineering industry of Czarist Russia, was concentrated mainly in two areas: in the Urals (based on the iron-ore deposits of Magnitogorsk) and in the south of Russia (based on the iron-ore deposits of Krivoi Rog in the Crimea and on the coal of the Donets basin). Some industrial areas, for instance that of St. Petersburg, relied to a great extent on imported raw materials and coal, which were cheaper than the Russian products owing to cheap sea transport.

This picture has now changed. Although the south of Russia and the Urals still remain the largest centres of the metal industry, a number of new industrial areas have been developed. New blast furnace plants and steelworks have been erected in the Chelyabinsk region (north of Moscow), Central Asia (Karaganda), the Caucasus, the Crimea, and the Far East. Apart from the desire to bring the steel nearer to the consumer, this distribution of the industry indicates a definite tendency to move it away from the vulnerable western frontiers towards the east, a trend which is based on strategical considerations.

NEW PROVEN ORE DEPOSITS

A considerable number of new iron ore deposits were found in recent years in Siberia, in the Urals and in Khazakhstan (Central Asia). New deposits were also discovered in the old mining areas, so that the Soviet Union now has a number of places where deposits are estimated at more than 1,000 million tons. For example, the deposits of iron quartzites (25-40 per cent iron) in the Krivoi Rog area are now estimated at over 50,000 million tons.

In the Kursk region the iron quartzite deposits (25 per cent Fe) are estimated at 200,000 million tons, and of a richer ore (58 per cent iron), at 250,000 million tons. These deposits are as yet not worked on a large scale.

At present about 50 per cent of all Russian iron ores are mined by open-cast methods and this percentage is being steadily increased, since open-cast mining offers better possibilities of mechanisation.

Although iron ore and coal are found in many places in Russia, the vastness of the country and the absence of suitable waterways (most Russian rivers flow from north to south, or *vice versa*) involve transports by railway over very great distances and have a substantial effect upon the cost of production. For example, the blast furnaces and steelworks of the Urals region obtain their coal from the Kuznetsk region in Siberia, about 1,000 miles away.

SINTER AND HIGH TOP PRESSURE

In Russia, as elsewhere, an increase in the volume of blast furnaces is considered one of the most effective means of improving the efficiency and reducing the costs of the iron melting process. By increasing the size of new units and scrapping old furnaces the average volume of blast furnaces was increased in 1956 to 743 cu. metres. Only a few blast furnaces of less than 1,000 cu. metres are now built. The design of a 1,513 cu. metre standard furnace is already completed, a 1,719 cu. metre type is in the development stage and the necessary preparations are being made for the design of a 2,296 cu. metre unit.

Other measures which are being implemented with the intention of increasing the efficiency of blast furnaces are the maintenance of steady operating conditions, improved uniformity and quality of the charge, and increased use of agglomerated ore and fluxes.

For example, the Magnitogorsk metallurgical combine has been able to achieve a charge with the iron content varying only within $\pm$ 1 per cent by an appropriate mixing of ores during the mining operations, in transportation and in its subsequent handling at the blast furnace.

According to Soviet experience, the use of agglomerated charge components increases the output of furnaces by 10 to 25 per cent and enables the coke consumption to be reduced by 7 to 20 per cent. For this reason the use of agglomerated charge components has been doubled during the past 10 years and now reaches 1,090 kg per ton of pig iron. 87 per cent of all agglomerates are now fluxed by adding powdered limestone. By 1960 it is intended to extend this preparation process to all ores.

Other frequently used measures for increasing the output of blast furnaces and improving their efficiency are the increase of the gas pressure in the furnace top, the use of a constant-humidity blast, and an oxygen-enriched blast.

The average gas pressure at the furnace top is 0·8-0·9 atm in Soviet practice, while in the furnaces blown-in in recent years it is increased to 1·1 atm, and new furnaces are being designed for a pressure of 1·5 atm.

A number of Russian blast furnaces are now using blast with a moisture content of 25 g per cu. metre. This enables the output of furnaces to be increased by 7 per cent with a simultaneous reduction in coke consumption. 96 Russian blast furnaces now operate with blast of increased humidity.

HIGHER STEEL OUTPUT PER MAN

The largest refining furnaces used in the USSR have a capacity of 500 tons and a rated output of 60 tons per hour. A standard furnace of 700 tons capacity is at present in the development stage.

The relatively high average size of furnaces is not fully reflected in the yearly output per furnace. This is apparently due to a low standard of maintenance and to shortcomings in work organisation. In 1956 the output per cu. metre of hearth area was 7·21 tons in 24 hours. This figure has been steadily rising owing to improvements in organisation and supplies and the introduction of technical improvements.

Obviously the purpose of the increase in the size of furnaces is to achieve an increase in output and a reduction in the cost of products. The Russians found for example, that by increasing the size of the furnace from 185 to 440 tons the cost of the products fell by 3·5 per cent and the capital cost by 12·9 per cent, while the output per man increased by 31·8 per cent.

Oxygen is used for boosting the melting process and experience shows that this enables an increase in output of up to a fifth. In 1960 it is intended to produce nearly half all steel (including all of Bessemer steel) with oxygen.

On increasing the oxygen content of air supplied into the furnaces at the "Zaporozhstal" works by a quarter, the melting time of a heat was reduced from 9 hours to 7½-8 hours.

Oxygen is also used for improving the quality of steel produced by the Bessemer process. A plant of this type consisting of two 20 cu. metre converters is, for example, in operation at the Petrovskii metallurgical works.

80 per cent of Russian open hearth furnaces now have magnesite-chromite roofs; this percentage is claimed to be the highest of all steel producing countries. A campaign of furnaces with such roofs was found to be 2 to 3 times longer than that of furnaces with Dinas roofs; they also enable the process to be run at a temperature about 100° C higher.

The maximum capacity of electric arc furnaces now in operation in the Soviet Union is 50 tons; 80 ton units are already under construction and the next Five Year Plan provides for the installation of 180 ton furnaces.

Revolutionary changes in the manufacture of steel are expected from the introduction of continuous ingot-casting machines. Eight experimental plants of this type on an industrial scale were already in operation in 1956. The experimental plants are of vertical and inclined type, fitted with stationary and travelling crystallizers and with continuous and intermittent ingot travel. The capacity of the ladles used in this process is being increased from 10—50 to 50—130 tons. In view of the results obtained it is hoped that the process can be used on a large scale in the production of rimmed and killed carbon steel of various grades. When fully developed this process will in many cases make unnecessary the use of blooming and slabbing mills and of soaking pits and reheating furnaces. The combination of the continuous-casting plant with a continuous rolling mill will be a big step forward in the automation of steel manufacture.

Although the Russians are leading in many fields of automation, they frankly admit that they are lagging behind other countries in the automation of steelmaking processes and especially of the auxiliary operations of steel production.

NEWTONIAN THEORY *of* AXIAL ELASTICITY *Part 1*

By A. N. PROCTER
M.Sc., A.M.I.C.E., M.I.Struct.E.

The usual behaviour of ordinary elastic materials under the action of simple forces and their modes of failure are in many ways incompatible with a general assumption that the internal stresses produced by axial loading are uniformly distributed throughout the volume or entirely normal to the cross-section of a member or test piece. Transverse distortions, lateral deflections and oblique failures under axial loading, and also the effect of the shape and proportions of test pieces on the apparent ultimate strengths of the materials, all appear to indicate that, in addition to the axial forces produced by the externally applied loads, there may be other local or distributed internal forces or stresses

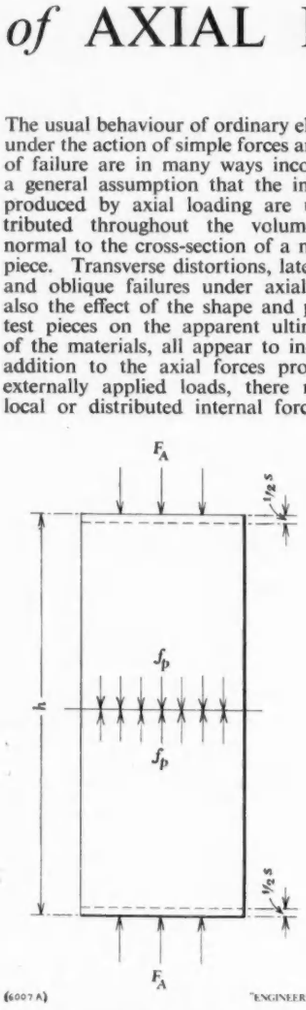


Fig. 1 Uniform prism or cylinder to which equal and opposite axial forces are applied.

acting to bring about these "incompatible" phenomena.

It is recognised that conditions of loading or avoidable imperfections in the shape or materials of the test pieces may induce consequent secondary stresses or bending stresses, but the occurrence of some kinds of failures and deflections is so invariable that the question arises as to whether the whole or part of these phenomena may be brought about by the properties of the materials. The nature of axial elasticity is here considered from several aspects and conclusions are drawn from the established normal results of elementary mechanical tests and methods of research in the light of accepted Newtonian principles and science. The materials considered are those regularly used in engineering construction in either a natural or manufactured state, mainly on account of their elastic and durable properties or strength.

Newton's final conclusions on the subject of elasticity are given in the third book of *Opticks* (Question 31 and query 21)[1] and his suggestion that elasticity is produced by the elementary forces between particles of matter received fairly general assent during the two centuries following its publication. During the last half century the increased knowledge of the nature and reality of the internal forces in all kinds of materials has provided remarkable confirmation of Newton's intuition. He defined an elastic material in the following words: "If a Body is compact and bends or yields inward to Pression without any sliding of its Parts, it is hard and elastic, returning to its Figure with a Force rising from the mutual Attraction of its Parts." Using these general principles as a starting point, a number of problems relating to the action of simple compressive and tensile forces on solid elastic materials may be reconsidered.

Hooke's Law provides a simple expedient whereby the relations between the axial stresses and elastic strains may be expressed in simple mathematical forms, so that engineers have been able to derive general expressions of considerable value that cover a wide range of problems. There is, however, a large variety of reasonably elastic materials used in engineering and the practical application of Hooke's Law is confined only to a number of them. Since Hooke did not consider the complementary transverse strains of elastic materials, no provision is made for this part of the problem in the "law." Certain qualifications therefore appear to be needed in its application, setting limits to the fields of inquiry, where it gives reliable results.

COMPRESSION TESTS

The most valuable method of investigating the elementary properties of elastic materials under axial loading is by compressing and crushing prisms or cylinders of brittle materials between the parallel plates of a testing machine. Provided that the ends of the test pieces are machined to give an even bearing on the compression surfaces of the machine, it is probably inadvisable to interpose soft materials between the bearing surfaces and a thin layer of suitable lubricant will minimise the effect of the end friction. Since, however, the tests are to some extent a comparison of the properties of the materials and of the effect of the sizes and proportions of the test pieces, rather than an exact measurement of the specific strength in compression of the materials, it is important that the methods of testing should be uniform, thereby reducing, as far as possible, the number of variable factors to be considered.

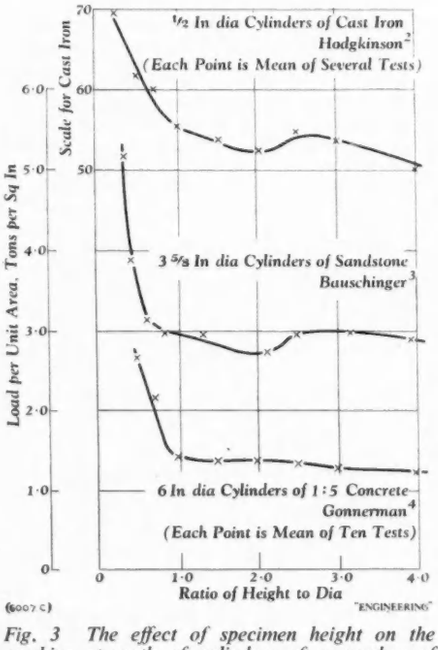


Fig. 3 The effect of specimen height on the crushing strength of cylinders of a number of brittle materials.

Considering, therefore, a uniform prism or cylinder of elastic material to which equal and opposite axial forces, F_A, are applied at the ends, let it be assumed that, at a normal cross-section, the adjacent particles of the material exert equal and opposite unit forces or stresses, f_p, as in Fig. 1, so that the sum of the forces, f_p, is equal to the applied force, F_A. If, however,

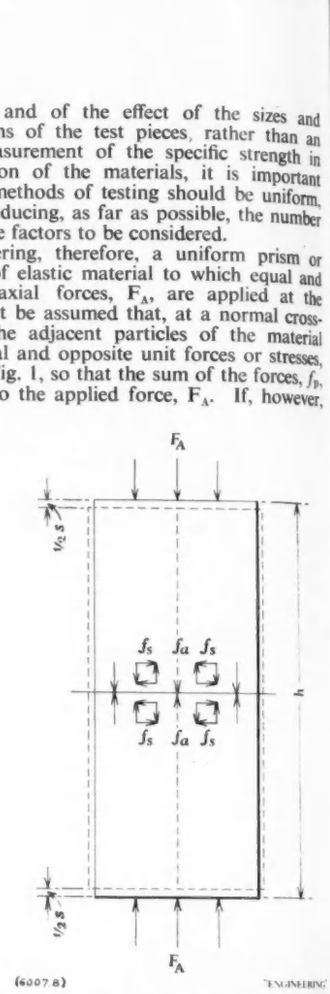


Fig. 2 Forces between particles may be resolved into unit axial forces or stresses, f_a, and unit shear forces or stresses, f_s.

all the internal forces, f_p, are assumed uniformly distributed over the cross-section and also coaxial with the applied forces, F_A, there could be no strain normal to the axis of the test piece, since neither the applied nor the internal forces would have a component in that direction. This appears to follow directly from Newton's Second Law of Motion:—The rate of change of momentum is proportional to the applied force and takes place in the direction in which the force acts. Since it is established by experiment that under the conditions considered there always is a transverse strain in an elastic material, it might follow that the internal forces, f_p, are not all quite parallel with the applied forces. This being so, the forces, f_p, between the particles, may be resolved into unit axial forces or stresses, f_a, and unit shear forces or stresses, f_s, as in Fig. 2; the transverse strain being produced by f_s, here described as the axial shear stress, the strain being radial, unlike shear strains which are produced by transversely applied forces.

Apart from the otherwise unexplained transverse strain, the evidence that axial forces are able to produce shear stresses in elastic materials, when the materials are overstresses or are crushed, are the phenomena of Lüders' lines and of slip

bands that indicate a diagonal slipping or relative movement of the surface particles at the yield point and the proportional limit of certain materials. The crushing of many brittle materials displays the unmistakeable signs of shear failure, or of failure accompanied by shear, and in some materials there is evidence of shear failure under tension. It has been said that the stresses that produce these appearances of shear strain and shear failure of the material suddenly develop as the result of a general breakdown of the internal structure, though the events leading up to this are not capable of clear explanation. A careful examination of available reliable data, reinforced by the direct application of Newton's methods of scientific research, are sufficient to show that Newtonian mechanics gives results consistent with the facts.

Compression tests on brittle materials carried out by Professor E. Hodgkinson,[2] Professor J. Bauschinger[3] and many other research workers have shown that the size and proportions of the test pieces have a considerable influence on the unit crushing strength, a noticeable factor in the strength of short test pieces being the ratio of the height to the thickness or diameter. A variety of cross-sectional shapes and sizes of test pieces have been used and, for the purpose of simplification, the results of tests on the crushing strengths of cylinders are illustrated in Fig. 3, where the values of the crushing strength are plotted against the ratio of height to diameter (h/d). The crushing strengths of the cylinders, for $h/d = 0$ to 1·5, get progressively less as h/d increases. At certain ratios of h/d (about 2 : 1 for ½ in diameter cast iron cylinders and about 1½ : 1 for 1 to 5 mix concrete cylinders) the crushing strengths attain minimum values. Beyond this point the strengths are fairly constant, so that it appears that a change may have taken place in the internal stress conditions. Similar results are obtained when prisms of other cross-section are used, so that it appears that the phenomen is induced mainly by the h/d ratio and by the properties of the materials in each case.

Assuming that the internal stresses are as illustrated in Fig. 1, it is difficult to explain these results, but if the arrangement of stresses indicated in Fig. 2 is assumed, it is possible to arrive at a simple mathematical representation of the facts by means of a strain energy calculation. The internal energy per unit volume would be $\frac{1}{2} f_a \frac{s}{h}$, axial strain energy, and $\frac{1}{2} f_s \phi$, shear strain energy, ϕ being the strain produced by f_s. Assuming the conditions of Hooke's Law, these expressions might be re-written: $\frac{1}{2} E \left(\frac{s}{h}\right)^2$ and $\frac{1}{2} G \phi^2$ per unit volume. Since Hooke's Law may not be applicable, the qualifying coefficients α and η are introduced to provide for possible variations in the distribution of the axial and shear stresses. The volume of the test piece is A h, A being the area of the cross-section, so that the total strain energy would be

$$\frac{1}{2} \alpha E A \frac{s^2}{h} + \frac{1}{2} \eta G A h \phi^2.$$

Equating this to the work done by the applied force F_A:

$$\frac{1}{2} F_A s = \frac{1}{2} \alpha E A \frac{s^2}{h} + \frac{1}{2} \eta G A h \phi^2$$

so that

$$F_A = \alpha E A \frac{s}{h} + \eta G A \phi^2 \frac{h}{s}. \quad (1)$$

It is clear from equation 1 that, when h is small, a large part of the applied force is absorbed in direct compression and only a small part in shear, but for large values of h the applied force would be absorbed mainly in shear. Fig. 4, 5 and 6 show the modes of failure in compression of cast iron, concrete and sandstone test pieces, and it can be seen that the short test pieces have failed mainly by crushing and the longer test pieces mainly by shearing, as suggested by equation 1. In order to find the condition when

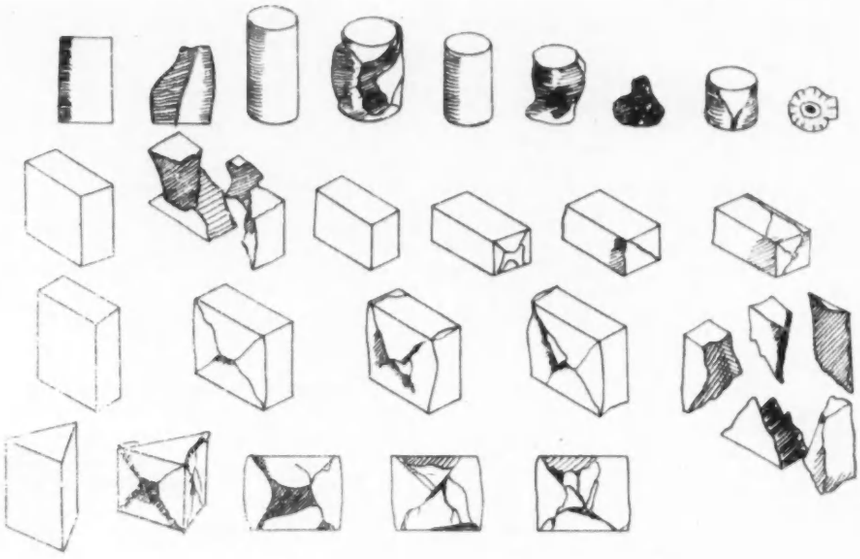


Fig. 4 (above) Modes of failure in compression of cast iron cylinders and prisms. Tests by Professor E. Hodgkinson.[2]

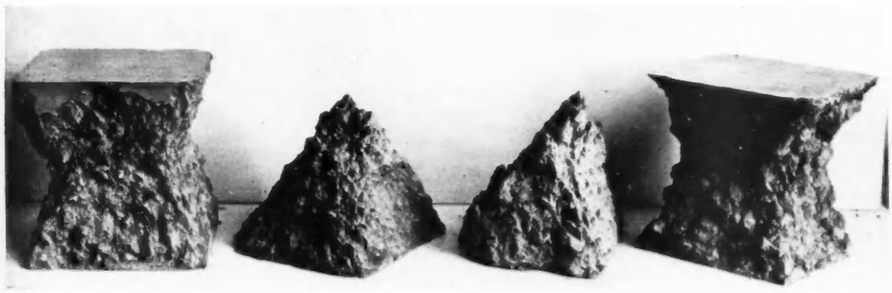


Fig. 5a (above) Typical failures in compression of 6 in diameter concrete cubes. Failure is partly by crushing and partly by shearing. Tests by Messrs. Stanton Ironworks Company Limited, Nottingham.

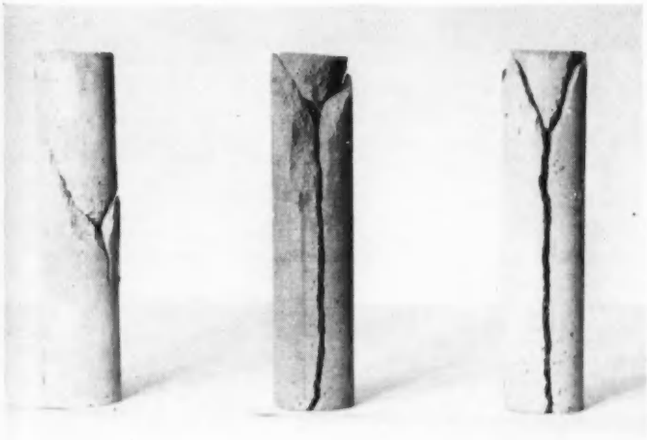


Fig. 5b (left) Typical shear failures of 4 in diameter by 16 in long concrete cylinders in compression. Tests by Dr. A. M. Neville of Manchester University.

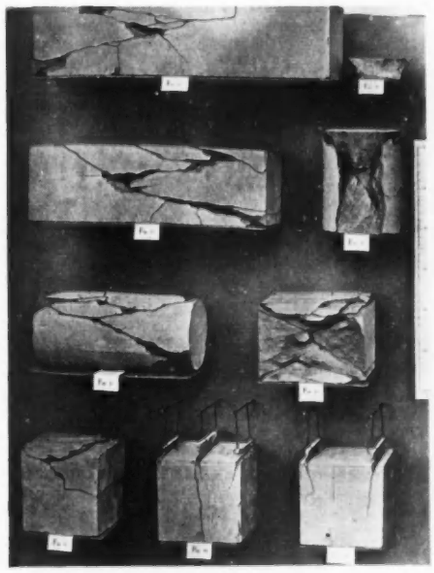


Fig. 6 (above) Modes of failure of sandstone cylinders and prisms in compression. Tests by Professor J. Bauschinger.[3]

F_A reaches a minimum value, equation 1 should be differentiated with respect to h and equated to zero (a Newtonian device):

$$\frac{dF_A}{dh} = -\alpha E A \frac{s^2}{h} + \eta G A \frac{\phi^2}{s} = 0$$

and the critical value of $h = \frac{s}{\phi}\sqrt{\frac{\alpha E}{\eta G}}$ and the critical value of

$$F_A = \phi A \sqrt{\alpha \eta E G} + \phi A \sqrt{\alpha \eta E G}$$
$$= 2 \phi A \sqrt{\alpha \eta E G} \quad . \quad . \quad . \quad (2)$$

From equation 2 it appears that F_A is now absorbed equally by the direct compression and by the shear, making the axial strain energy equal to the transverse strain energy. The failure now takes place in simple shear and by substituting

$$\phi = f_s/\eta G, \quad F_A = 2 \gamma A f_s \sqrt{\frac{E}{G}} . \quad (3)$$

In this equation $\gamma = \sqrt{\frac{\alpha}{\eta}}$ is a non-dimensional coefficient representing the effect of the shape of the section and certain properties of the materials and f_s is the critical shear stress.

The principal stresses occur on oblique planes and it is found that the angle of shear under compression of each material is fairly constant, depending to some extent on the proportions of the test piece. The shape of the cross-section of test pieces has some effect on the crushing strength. This is illustrated in Table 1, which gives results of tests on cast iron cylinders and prisms of various cross-sections carried out by Professor E. Hodgkinson,[2] for a given ratio of height/diameter (or height/thickness) the cylindrical cast iron test pieces have greater unit crushing strength than the prisms. In concrete, however, this effect is reversed, particularly for long test pieces, beyond the critical h/d ratio. When glass is tested in compression, there is no definite form of failure, the whole of the test piece being broken into irregular shaped fragments. The compression failure of most brittle materials extends through the height of the test piece, but the compression failure of timber is usually local, producing a short "wedge" with a length about half the thickness of the test piece.

TABLE I.—*Crushing Tests on Cold Blast Cast Iron by Professor E. Hodgkinson*[2]

Height of Test Piece, in	Crushing Strength, ton per sq. in					
	Solid Cylinders, diameter			Solid Prisms		
	¼ in	⅜ in	½ in	Equilateral Triangle circumscribing a circle of ½ in diameter	Square, ½ in × ½ in	Rectangle, 1 in × 0·243 in
¼	61·4 (*a*) 61·7	68·8 (*a*) —	65·5 (*b*) —			
⅜	—	57·3	62·0 (*c*) 61·1			
½	56·5 56·5	56·5 (*e*) —	55·4 56·2	49·3 (*d*) —	48·2 44·2 45·2 (*j*)	48·8 —
⅝	—	58·8	—	—	—	—
¾	53·8 55·2	56·5 —	55·6 55·4	46·6 —	44·2 42·8 (*j*)	48·7 —
1	52·5 53·2 (*g*)	57·3 —	56·3 55·8	43·5 (*f*) —	43·3 42·2 (*j*)	46·8 —
1¼	— —	57·3 —	55·6 53·7	Cylindrical test pieces were turned from bars cast ¼ in larger		
1½	—	55·3 (*h*)	53·9 (*i*)			

Notes:
(*a*) Flattened in middle and crushed round edges.
(*b*) Reduced in thickness to 0·1 in and broken round edges.
(*c*) Crushed except at centre.
(*d*) Fracture a pyramid, splitting three sides, one base whole.
(*e*) Bulged out in middle before breaking.
(*f*) Fractured by ends forming bases of pyramids.
(*g*) Specimen slightly bent, wedge 0·46 in long.
(*h*) Specimen cracked across middle after bending a little.
(*i*) Bent a little, 1 ton before fracture; wedge broke 0·56 in long.
(*j*) Specimen cut from the middle of a 1¼ in bar.

TABLE I.—(Continued)

Height of Test piece, in	Crushing strength, tons per sq. in					
	Solid cylinders, diameter				Solid prisms	
	¼ in	⅜ in	½ in	0·64 in		
⅛	79·8 (*a*) 74·2	76·7 (*b*) —	69·5 (*c*) —	—	Square ½ in by ½ in, (cut from bar 1 in square)	Rectangular 1 in by 0·26 in (cut from bar 1¼ in square)
¼	60·7 (*d*) 64·7	60·5 71·5	57·4 (*e*) —	—		
⅜	60·7 59·0	54·1 —	57·4 —	—		
½	58·3 58·3	54·1 —	54·3 55·2 54·8	—	45·3 46·8	47·8 —
⅝	57·8 57·3	56·0 —	—	53·6 —	—	—
¾	—	63·2 63·8	49·2 —	49·6 —	42·7 —	—
⅞	—	—	—	49·6	—	—
1	—	63·5 —	48·0 48·0	—	—	42·5 (*f*) —
1¼	—	—	54·4	—	Cylindrical test pieces turned from bars cast ¼ in larger in diameter	
1½	—	59·5	52·6	—		
2	—	56·2	49·8	—		

Notes: (*a*) Not crumbled, flattened.
(*b*) Flattened and cracked round edges.
(*c*) Reduced in thickness about half and cracked round edges.
(*d*) Crushed. (*e*) Reduced and split round edges.
(*f*) A wedge nearly equilateral formed at top and bottom which split sides.

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[1] Sir Isaac Newton, *Opticks*, Fourth Edition (1730). Republished by Dover Publications Inc., New York (1952). See Also I. Todhunter and K. Pearson, *History of the Theory of Elasticity and Strength of Materials*, pp. 16, 26 and 93, vol. 1. Cambridge University Press (1886).

[2] Professor E. Hodgkinson, "On the Relative Strength and other Mechanical Properties of Cast Iron Obtained by Hot and by Cold Blast." 7th Report, British Association, p. 337 (1837-38).

[3] Professor J. Bauschinger, "Experimentelle Untersuchungen über die Gesetzden der Druckfestigheit." *Mitt. aus dem Mech-Tech. Lab. der K. Tech. Hochschule in München*, vol. 7 (1876). See also W. C. Unwin, *Testing Materials of Construction*, p. 396, Longmans, Green and Company, London (1899); or Johnson's *Materials of Construction*, pp. 113-119, John Wiley and Sons Inc., New York (1939).

[4] Harrison F. Gonnerman, "Effect of Size and Shape of Test Specimen on Compressive Strength of Concrete." *Proc. Amer. Soc. Test. Mat.*, p. 237, vol. 25, Part 2 (1925). See also "A Report on Standardizing Tests and Testing Methods," *Concrete-Cement Age*, p. 141, vol. 4 (March 1914), and John W. Murdoch & Clyde E. Kesler, "Effect of Length to Diameter Ratio of Specimens on the Apparent Strength of Concrete." *Bull. Amer. Soc. Test. Mat.*, pp. 68-73, April 1957.

Parts 2 and 3 of this article will be published in ENGINEERING later

BLADE FREQUENCY OF TURBINES

We regret that the article Blade Frequency of Turbines, Effect of Disc Elasticity, by Mr. J. P. Ellington and Dr. H. McCallion, was published in our issue of 15 May in uncorrected form. On page 645, column 3, the expression for D should have been written:

$$D = \frac{A(1 + \cos \lambda L \cosh \lambda L - \sin \lambda L \sinh \lambda L)}{(\cos \lambda L \sinh \lambda L - \sin \lambda L \cosh \lambda L)}$$

In equation (4), r and $r + 1$ should have been suffixes. In equation (6) the solidus should have been a multiplication sign and the L_1 in the denominator should have been an I_1. On page 646, equation (8) in column 1 should have read: $\theta_r = P \cosh \phi r + Q \sinh \phi r$ and the first two lines of equation (9)

$$O = \theta_1 - 2 \cosh \phi \, \theta_0 + \theta_N$$
$$= P \cosh \phi + Q \sinh \phi - 2 P \cosh \phi + P \cosh \phi N + Q \sinh \phi N$$

On the same page, column 2, N and N − 1 should have appeared as suffixes, and in the eighth line below, the minus sign following (N + 2) should have been an equals sign. Reprints of the corrected version will be available from D. H. McCallion, Mechanical Engineering Department, University of Nottingham.

LARGE IMPACT MACHINE

A large impact machine, capable of delivering 500,000 ft-lb of energy to a test specimen, has been installed at the Naval Construction Research Establishment, Dunfermline, Fifeshire.

The machine is to be used in connection with research into the behaviour of the various steels and welded joints used in warship construction, under high rates of loading. It is expected that much of the information obtained will be of a fundamental nature, of value in several branches of engineering and steelmaking.

Consultants for the project were Professor J. F. Baker, F.R.S., Mr. A. M. P. Brookes and Mr. J. L. Reddaway, of Cambridge University.

On the Shelf

By Frank H. Smith

Technical authors (as opposed to technical writers) will be interested to hear that the Institute of Physics has brought out a revised edition of their "Notes for Authors" with the sub-title "A guide for contributors to the Institute's Journals and other publications." This guide was first published in 1931 so the accompanying bibliography has had plenty of scope for revision and as a matter of fact, out of about 20 items quoted only one, judging by its date, could have appeared in the earlier version. This is Fowler's *Dictionary of Modern English Usage*. Nineteen odd other items bear witness to a modern awareness for instruction in technical writing. The booklet is available from the Institute at 47 Belgrave Square, London, SW1, for 3*s* 6*d*.

From time to time, in a diffident sort of way, I mention the works of reference put out by Europa Publications (56 Bloomsbury Street, WC1). I say diffident because they are in the upper price bracket round £6, but if you want to know all about all their publications, Europa now have a descriptive booklet of their complete list.

The *Engineering Journal* of General Motors for second quarter 1959 contains a list of papers and lectures given by GM staff recently. There are 17 items on automotive engineering, about 20 to the SAE annual meeting, four from the foundry department, nine on guided missiles, six from manufacturing, five on mathematics and computers, three metallurgy, 13 "miscellaneous," six on personnel development and three on research. There must be a Professor of Technical Writing lurking somewhere round that organisation.

Constable, of 10-12 Orange Street, London, WC2, issue their 1959 list with the reminder that they also do the Athlone Press and Thames and Hudson (anglice) and Dover Publications. The latter are not included in the list, though they do mention six mouthwatering forthcomings. Incidentally, a good Dover is *The Devil's Dictionary*, a very clever "spoof" lexicon with definitions of words better suited to their contemporary interpretation than the more conventional definition. It's the whole of Orange Street to a china lombard that this book will be much in demand. Did you know that a china orange is a particularly ugly potato?

The machine sales department of Henry Simon Limited, Cheadle Heath, Stockport, have issued No. 1 of a little news-sheet called *Industrial Plant Review*. They do a "wide range of industrial machines" so a postcard may bring you something you need. The first number includes a pepper mill, Cadbury's starch cleaning, a bin level controller and a grinding machine.

It may not be generally known (I did not know until I received Bulletins 4-5) that there is a Provisional International Computation Centre established by contract between UNESCO and the Istituto (sic—no "n") Nazionale di Alta Matematica (sic—no "h"). In this bulletin I mentioned, they start the "International Repertory of Computation Laboratories" wherein are listed the name of the lab., its officers, what it does, equipment, projected equipment, special experience, training and publications. If you wish to know more, write to the Director, Jean A. Mussard, Palazzo degli Uffici, Zone dell'EUR, Rome.

Eight volumes will be published during 1959 under the general heading of *The Survey*. This covers various aspects of the Brussels exhibition and each volume has a different theme and a different price. For particulars write General Commissariat of the Brussels Universal and International Exhibition, 1958 (on a small envelope use three lines), Publications Service, Avenue du Parc Royal, Brussels 2.

ELECTRON JUNCTION

Progress in Semiconductors. Vol. III. Edited by A. F. GIBSON, P. AIGRAIN and R. E. BURGESS. *Heywood and Company Limited, 9 Kingsway, London, WC2.* (55*s*)

An Introduction to the Theory and Practice of Semiconductors. By A. A. SHEPHERD. *Constable and Company Limited, 10 Orange Street, London, WC2.* (18*s* 6*d*)

The Junction Transistor and its Applications. Edited by E. WOLFENDALE. *Heywood and Company Limited, 9 Kingsway, London, WC2.* (84*s*)

A third volume in the annual series "Progress in Semiconductors," appears with another collection of important papers on aspects of semiconductors ranging from theory and physical properties to engineering, as represented by the papers on the "Chemical Purification of Germanium and Silicon," by J. M. Wilson and "Silicon Junction Diodes," by D. E. Mason and D. F. Taylor. The papers concerning the properties of semiconductor materials contain much that is of topical interest. Thus the paper by J. Lambe and C. C. Klick on "Electronic Processes in Cadmium Sulphide" appears at a time when much interest is being devoted to cadmium sulphide as a radiation detector, as a light source and also as a new material for use in non-linear circuit elements. The paper is also notable for its treatment of the optical and conducting properties of the material as related aspects of a unified theory. On the engineering side, the paper on material preparation by J. M. Wilson gives a very clear appreciation of the magnitude of the problem of purifying the raw materials, combined with a lucid and very readable account of the processes used. No user of semiconductor devices can fail to be impressed upon reading of the work which is involved in the production of pure forms of the basic materials.

This admiration will be sustained and extended to the device manufacturers after reading the contribution by Dr. Mason and Dr. Taylor on "Silicon Junction Diodes." The theory of junction diodes is first reviewed, followed by descriptions of the main fabrication processes and a section on the characteristics of the various types of diode. Among other things the paper illustrates the significant advances which have taken place in the understanding of semiconductor devices in recent years; and stemming from an improved understanding, better devices have followed. This paper in particular should provide very profitable reading for circuit engineers.

The modestly sized (and priced) book by Dr. Shepherd is in contrast mainly aimed at the honours student in physics, and deals with the technology of semiconductors, describing most aspects of both the preparation of monocrystalline material and the fabrication of rectifiers, transistors and photocells. In view of the continued expansion of the semiconductor field, such a book will be welcomed not only by the physics student requiring a concise summary of up-to-date theory and practice, but also by readers from many other fields, who are almost certain to be using some semiconductor devices in the future.

This book, which has been written by the head of an industrial semiconductor development laboratory, admirably fulfils this need, and the author has succeeded in presenting basic semiconductor theory in a very understandable manner which should appeal to newcomers to the subject. The sections on devices which follow are notable for the clear and simple manner in which the device construction and materials are shown to be chosen to give the required electrical performance. The way in which the characteristics may be accounted for by reference to the basic theory should perhaps dispel that aura of "black magic" which surrounded some of the earlier books on transistors. The author is to be particularly commended for including very full lists of references to original work; this will benefit those readers who wish to study the subjects in greater detail.

Unfortunately, the editor of the next book has been unable to rid himself of another kind of "black magic," namely the use of mathematics where none is needed. *The Junction Transistor and its Applications*, edited by E. Wolfendale, despite a rather forbidding title turns out to be largely a collection of Mullard reports which have already appeared in various forms, slightly rewritten in order to fit within the end covers of a book. As such, the book is by no means the exhaustive account of the junction transistor which its name implies, but is largely concerned with the use of transistors in the entertainment market, although a rather incomplete account of non-linear applications and some computer-type circuits is also included.

As already mentioned, the book's main fault lies in the uniform disbelief of the various authors in the ability of the reader to perform simple algebra for himself. This is probably a hangover from the more spacious pages of report writing, but it has the effect that the reader becomes quickly sated and fails to discern the underlying information. Despite this fault, however, the determined reader may extract considerable benefit from the book, which will lead him from transistor physics in the first chapter, through characteristics and equivalent circuits, to a description of the various circuit techniques which are current in general sinusoidal applications, naturally with some emphasis upon the profitable domestic radio field. He may even notice some numerical inconsistencies between different authors in various chapters; also, no doubt he will forgive the derivation of the same equivalent circuit upon no less than four separate occasions in various parts of the book.

READY RECKONING

How to Calculate Quickly. By HENRY STICKER. *Dover Publications Incorporated, 920 Broadway, New York 10, NY, USA* ($1); and *Constable and Company Limited, 10-12 Orange Street, London, WC2.* (8*s*)

Arguments about methods of teaching skills often revolve about the relative merits of on-the-job training and "taking a course." Yet the two methods are largely complementary: whereas a course can cover a whole field and supply unifying theories, "on-the-job" training provides a constant reminder of the real conditions under which the skill must function.

Mr. Sticker's book is a course. Apart from the occasional use of dollar signs—for this, of course, is an American book—there is no attempt to relate the material to practical situations. By means of 383 graded exercises (allowing some 15,000 calculations) the reader is encouraged to solve increasingly complicated problems of elementary arithmetic, mostly in his head. Very roughly we employ two tools in calculation: method and memory. The author has chosen the easier course for a teacher of placing his emphasis on memory. The reader is expected to learn his multiplication table up to 25 times 25, while the addition sums are designed to develop familiarity with every possible combination of two-figure numbers. (The exercises on handling fractions and common decimals are based almost entirely on memory.) The main stress on the methods side is on working from left to right, and on adding lists of small numbers

in bunches of two or three. Finally, there is some discussion of "short cuts," such as techniques based on quadratic equations for solving certain multiplication problems.

Although this is a theoretical book the theory is more apparent in the carefully graded exercises than in exposition and discussion. We are told, for example, during addition: "do not consciously repeat to yourself the individual amounts you are adding, but only the successive total." But there is no further comment on the complicated psychological and philosophical questions thus raised.

Experienced calculators will gain little in speed from a study of this book, in return for much irritation and impatience. But it could be useful as a refresher course for those whose mental agility at handling and retaining figures needs exercising. The author includes among these the many in "the engineering professions . . . who require slide rules to perform calculations the average billing clerk would perform mentally."

How to Calculate Quickly was originally published in 1945 by Essential Books (New York) under the title of *The Art of Calculation*. The present edition is a reproduction "with corrections by the author" in the Dover Publications series of technical paperbacks, and first appeared in 1955.

TEXT WITH VISUAL AIDS

Basic Electricity—Parts One to Five. A Course of Training Developed for the United States Navy by VAN VALKENBURGH, NOOGER AND NEVILLE, INC. *The Brolet Press, New York*; and *The Technical Press, 1 Justice Walk, Chelsea, London, SW3.* (12*s* 6*d* per part and 55*s* per set.)

Basic Electricity has been produced in five volumes and in the original edition provided an illustrated course of technician training for the United States Navy. It has since been adapted to British notation and terminology by a REME team at Arborfield, and a decision has been taken to adopt the revised texts for the training of future REME technicians. Such is the background to these books and this should always be remembered when reading them.

Firstly, the books are obviously American in both presentation of subject matter and illustration. The authors have tried to explain to a person of reasonable intelligence, with no prior knowledge of the subject, the fundamental aspects of electricity and, building up on this foundation, have in the later volumes, dealt in some detail with such subjects as generation of both alternating and direct voltages.

The emphasis throughout is on illustration, and the text assumes secondary importance. Illustrative diagrams have been freely used, as have analogies. Some of these diagrams are amusing, some startling, and some unfortunately incorrect. This is probably the worst feature of these books. If such emphasis is to be made on illustration then there must be no possibility of misleading the observer (one is tempted to dispense with the term reader!). For example: page 154 shows a coil passing a current and generating lines of magnetic flux. The text goes on to state: "to further increase the flux density an iron core is inserted in the coil." Correct—but the diagram infers no net increase in flux but merely increase in density in one part of the circuit. Again, on page 183, the diagram conveys the impression that the positive and negative charges repel. In the diagram on page 315 a student could be forgiven if he were to interpret heat and temperature as being synonymous. On page 347, the illustration may suggest to a student that copper has a relative permeability considerably less than one. All this implies that these books must be used with caution. There are some excellent illustrations, however, and teachers of the subject could well make freer use of similar diagrams.

These books will, I am sure, be extremely useful for the armed services technician, but the student technician in the technical college may find the approach in the earlier volumes a little disturbing. The idea of electron flow is used throughout and mention of current flow implies electron current flow. Consequently the Right Hand Generator Rule now becomes the Left Hand Rule. This is not necessarily confusing except where students are expected in practice to deal with conventional current flow. Probably a City and Guilds electrical installation student would find Volumes III and IV useful in his study of a.c. theory, but some points are so laboured as to confuse rather than aid.

It is very doubtful whether the approach would be acceptable in grammar schools but the first volume could be used with advantage in secondary modern schools in its existing form. Briefly, these manuals are primarily designed for armed services use and will have disadvantages if introduced in other spheres.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Instruments

Electronic Recorder. CAMBRIDGE INSTRUMENT COMPANY LTD., 13 Grosvenor Place, London, SW1. The model DE electronic recorder may be used with equipment for the measurement of temperature, gas concentration, pH, conductivity of solutions, radiation intensity, etc. Details of construction, performance and applications of the recorder are given in List 186.

Digital Computer. STANDARD TELEPHONES AND CABLES LTD., 10 Essex Street, Strand, London, WC2. The "Stantec Zebra" computer is intended mainly for scientific and mathematical research. It uses serial/binary mode, has word length of 33 binary digits and word time of 312 microseconds. It can also be used as the control centre for a small or medium sized data processing system. Illustrated leaflet L/102.

Communications. MARCONI INSTRUMENTS LTD., St. Albans, Hertfordshire. Signal sources, frequency meters, oscilloscopes, Q-meters, spectrum analysers, etc. Catalogue printed in English, French, German and Spanish.

Photoswitches. ELCONTROL LTD., Wilbury Way, Hitchin, Hertfordshire. Photorelays with small viewing heads and light sources, particularly suitable for photoelectric control of complex machinery, where space is limited. Data sheet PR1.

Transistorised Instruments. DAWE INSTRUMENTS LTD., 99-101 Uxbridge Road, Ealing, London, W5. Type 421 transistor oscillator has continuously variable frequency range of 20 c/s to 20 kc/s. Type 715 transistor frequency meter, weighing 6 lb, is designed for direct measurement of signals of widely different waveforms in the range 10 c/s to 30 kc/s. Illustrated leaflets.

Electrical Testing. AVO LTD., Avocet House, 92-96 Vauxhall Bridge Road, London, SW1. Universal meters, valve test meters, bridges, valve voltmeters, signal generators, d.c. amplifier, power factor and wattage unit, light meter, accessories, etc. Catalogue.

Industrial Television. EMI ELECTRONICS LTD., Hayes, Middlesex. Closed circuit television system with numerous recommended applications including visual control of widely separated operations, observation of dangerous processes, training, demonstrations and transmission of complex data such as blueprints. Illustrated leaflet.

Load Indicator. ELECTRICAL REMOTE CONTROL COMPANY LTD., The Fairway, Bush Fair, Harlow, Essex. Automatic load indicator unit type AL1 is suitable for testing mass produced domestic appliances, contactors and motors with overload protection. Illustrated leaflet.

NEW BOOKS

Technical Reports of the Electrical Research Association, *Thorncroft Manor, Dorking Road, Leatherhead, Surrey.*

"The Development of a Method for Measurement of Strains in the Blades of a Windmill Rotor," by J. G. Morrison, C/T117 (24*s*); "Radiation Losses from the Arc Column," by H. Pelzer, G/XT164 (15*s*); "Stability Reignition Time and Other Features of the Cold Arc," L/T362 by A. E. Robson (6*s*); "Effects of Irradiation on the Dielectric Properties of Polythene," by E. Rushton L/T377 (10*s* 6*d*); "The Steel/90° Sapphire Meter Bearing. Further Research on Life and Debris Formed," by G. F. Shotter, T/T55 (15*s*); "Does Stray Alternating Current Corrode Water Systems? Investigation of Installation at Rochdale," by G. Mole and D. P. Hammond, V/T138 (15*s*); "Combustible Industrial Gases—Possibilities of Ignition by Particles of Light Alloys Heated by Arcing or by Frictional Impact. An Appraisal of Published Information," by W. B. Whitney, D/T104 (12*s* 6*d*); "Intrinsically Safe Electrical Apparatus. Relation of Igniting Current to Inductance for a Mixture of Isohexane with Air," by E. R. Wooding and F. Shaw, D/T107 (6*s*); "Ultra-High Frequency Gas Breakdown between Rogowski Electrodes," by W. A. Prowse and J. L. Clark, L/T365 (18*s*); "Analysis of the IEC and AIEE Sphere Gap Voltage Measurement Standards," by A. Morris Thomas, L/T369 (10*s* 6*d*); "A Double-Exponential Waveform Generator for Model Networks," by P. G. Kendall, V/T136 (7*s* 6*d*).

Précis de Métallographie. By LÉON GUILLET. *Masson et Cie, 120 Boulevard Saint-Germain, Paris 6e, France.* (*Fr* 1,800)

A handy pocket-size book in three parts—"Structure et Propriétés des Métaux et Alliages Métalliques"; "Étude de Quelques Alliages Industriels" and "Exercises." An excellent little book with which to polish up one's French.

Bemessungsverfahren. By BENNO LÖSER. *Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany.* (*DM* 26)

Methods of measurement collected, with a subtitle: Zahlentafeln und Zahlenbeispiele (numerical tables and examples) zu den Bestimmungen des Deutschen Ausschusses für Stahlbeton (in line with the provisions of the German committee for prestressed concrete); a sixteenth edition indicates (*a*) a continued demand, contro (*b*) a need for constant revision.

Hydraulique Générale. By ALBERT SCHLAG. Second Edition. *Dunod, 92 Rue Boneparte, Paris (6e), France.* (*Fr* 2,600)

The author, avoiding complicated matematics, deals not only with liquids but also with gases. For this reason the title of the first edition "Hydraulique générale et méchanique des fluides" has been curtailed.

Symposium de Métallurgie Spéciale. Organisé à Saclay les 27 et 28 juin 1957 par le Département de Métallurgie et de Chimie appliquée. *Centre d'Etudes Nucléaires de Saclay, BP2, Gif-Sur-Yvette, S. et. O, Paris, France;* and *Presses Universitaires de France, 108 Boulevard Saint-Germain, Paris.*

Papers presented to a symposium under the auspices of the Institut National des Sciences et Techniques Nucléaires. There is no contents list and no index to the fifteen papers, two of them by Britons. Uranium, titanium, zirconium, cobalt are among the materials considered.

Aerodynamik des Flugzeuges. Vol. I: Grundlagen aus der Strömungsmechanik Aerodynamik des Tragflügels. Part I. By H. SCHLICHTING and E. TRUCKENBRODT. *Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Germany.* (52·50 *DM*)

One of the foremost German writers on the subject discusses here the atmosphere, boundary layer theory, and aerodynamics at low and high speeds. Each chapter has an exhaustive bibliography and there are detailed name and subject indexes.

BLACKWALL TUNNEL IMPROVEMENTS

The new North Approach to Blackwall Tunnel under the River Thames, in London's east end, is more than half way to completion and ahead of schedule. Construction began in May, 1958, and is expected to be completed by late spring next year. A duplicate tunnel which will carry the southbound traffic (northbound will be restricted to the existing tunnel) will probably be begun at the end of this year.

The North Approach is being built in advance of the new tunnel to eliminate a traffic bottleneck that has long existed at the adjacent entrances to the East India Dock and the old approach to the tunnel. The contractor for the work now in hand is Cubitts Fitzpatrick, a combination formed by Fitzpatrick and Son (Contractors) Limited and the civil engineering department of Holland & Hannen and Cubitts. Fitzpatrick are an old established London concern specialising in roadwork and although Cubitt's civil engineering department is only twelve years old it has already successfully completed contracts for tidal works, dams, docks, bridges, railways and waterways.

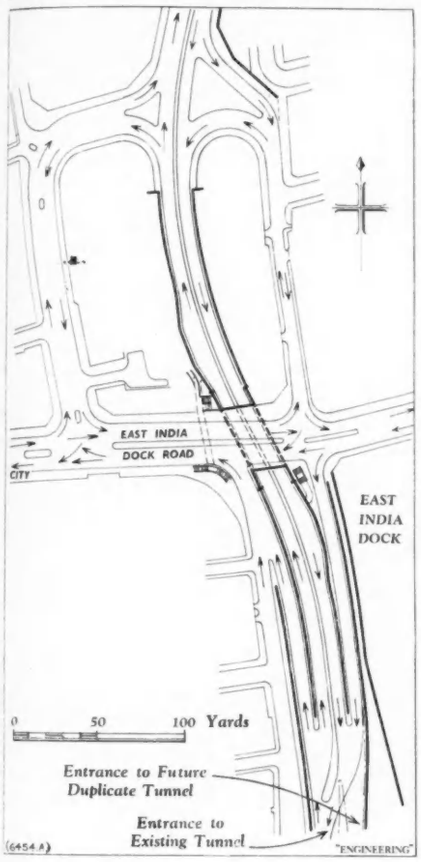


Fig. 1 (above) New approach and road improvements north of Blackwall Tunnel.

Blackwall tunnel was first opened in 1897. It was designed for horse-drawn and pedestrian traffic and the 16 ft wide carriageway, with sharp bends at the ventilation shafts, has long ceased to be adequate for two-way traffic. Powers to build a second tunnel were acquired by the London County Council in 1938 but the war intervened—and the traffic got worse. The line for the new tunnel is some distance downstream of the existing tunnel but will commence and finish adjacent to the existing approaches in East India Dock Road, Poplar, and Tunnel Avenue, Greenwich. The road configuration that is being built at the northern entrance is shown in the accompanying map.

The very heavy traffic in both directions along the East India Dock Road will continue to be carried at existing levels. The north/south and south/north traffic will use the dual carriageway of the new North Approach which will pass under the road and, on the north side, will feed into the new clover-leaf junction. As there is no space for a similar junction on the south side of the Road, slip roads are being provided. This will mean that some cross traffic movements will be unavoidable, but the arrangement should show great improvement over what has existed there in recent years. Part of these new traffic routes has already been put into effect and the full re-arrangement is being developed in five stages which will culminate in the North Approach being brought into use.

A new bridge having a skew span of 55 ft between abutments and supported on a central trestle will carry the East India Dock Road over the Approach. The bridge, at present under construction, is a composite structure of steel and reinforced concrete. It is being built in two parts so that the traffic can be kept moving and to permit two major high-pressure gas mains to be kept in operation. The mains, one on each side of the existing road, are 48 in in diameter and each has to be replaced by twin 36 in mains built within the deck of the bridge. Construction of the mains themselves, including the making of the new work into the old, is being undertaken by the Gas Board. Other services present similar though not so severe problems. During the construction of the bridge, east-bound traffic has been diverted round the new roads to the north and on completion of the northern half the west-bound traffic will be switched on to it to allow work on the southern half. The dumpling below the south-side roadway has been contained between placed sheeting held at the top by ties located in bore holes driven below the road surface; the toes of the sheeting are strutted off the invert concrete of the underpass.

The northern section of the work generally follows normal road construction practice in a cutting. The approach to the underpass is of heavy reinforced concrete, with the walls faced with Portland Stone. The pilasters are being faced with Westmorland slate. To give support to the foundations of tenament blocks on both sides, bored *in situ* concrete piles were put down. Their use eliminated the noise and vibration that would have been associated with driven sheet piles.

South of the East India Dock Road the construction is similar to that on the northern side, except that a very heavy concrete invert is required to counteract the higher water level, and the walls are heavily tanked by 1 in of asphalte. It is believed that there is a continuous seepage from the nearby dock through a wall that was damaged during the war. The work in progress on this southern side is shown in the photograph; the sheet steel piles of the cofferdam are supported by preloaded steel box struts. An old sewer below the new invert has had to be diverted.

To improve working conditions in the blue clay a curtain of well points has been laid along the east side of the site, to collect any seepage from the dock. Ultimately a permanent pumping station, on the south side of the work but close to the East India Dock Road, will remove all surface water from the Approach but until it is brought into use automatic pumps are keeping the excavations dewatered. The permanent pumps are being supplied by Lee, Howl and Company Limited of Tipton, Staffordshire, and each of the three pumps will be able to raise 500 gpm against a head of 40 ft.

The present works have involved 70,000 cu. yd of excavation and 22,000 cu. yd of concrete. The contract period is 27 months and the cost, including the work of the public utilities, will be about £750,000. Design and supervision of the work has been undertaken by the chief engineers department of the London County Council.

Fig. 2 (below) Work in the southern section of the contract, looking towards East India Dock Road. Traffic using the existing tunnel is on the old road behind the new work.

COLOMBO AID FROM INDIA

The entire cost of the Trisuli hydroelectric project is to be borne by the Government of India. Under the Colombo Plan the beneficiary of the scheme will be Nepal. The cost of the project will be about £2·55 million. The Government of Nepal will acquire the land and pay such compensation as may prove to be necessary.

The impression is sometimes given that aid under the Colombo Plan is a one-way traffic from the outside into South East Asia. This has never been true and the Trisuli scheme is an outstanding case of one Asian country offering financial assistance to another. Nepal is in a special relation to India and recent political events in Tibet are not calculated to reduce the interdependence of India and Nepal. Even when allowance is made, however, for the strong political incentive in India to help build up the standard of living in a small adjacent state, the project is a good example of the cross-fertilisation of ideas, technicians, and money which the Colombo Plan makes possible. If the machinery of the Plan were not there, it would be immeasurably more difficult to arrange these schemes than is now the case.

ARCHITECTURAL FINISHES WITH ALUMINIUM

A new office building completed in Hollywood has a gold-anodised aluminium curtain wall hung on black-anodised mullions; altogether 800 panels have been erected to make the walls. Horizontal sun shades of natural finish and grey-anodised aluminium run the width of the building at each of the 12 floor levels. Accenting

the ends of the sun shades are decorative panels of dusty red, yellow and green porcelain-enamelled aluminium. The building belongs to the First Federal Savings and Loan Association of the city.

The aluminium was supplied by Reynolds Metals Company and the contractor who erected the curtain walling, F. H. Sparks Company of New York City.

Engineer and Architect Collaboration

Collaboration between engineers and architects on concrete work is to be the subject of a special study undertaken jointly by this year's recipients of the Truscon Travelling Scholarships. Each scholarship is valued at £125 and will enable the winner to undertake a continental tour of about three weeks' duration. This year's recipients are Mr. D. F. Smith, B.E., of Truscon's own Liverpool office, and Mr. Peter Whiteley, A.R.I.B.A., who is in private practice in London.

Hyperbolic Roofs for Commonwealth Institute

The new Commonwealth Institute in London will have the main galleries under a roof composed of five meshing hyperbolic paraboloids, together covering a square area of 190 ft by 190 ft. The roof will be supported by only four columns, one at each corner. The paraboloids will build up from a mesh of precast post-tensioned concrete ribs decked with wood-wool slabs, a concrete screed (to give weight to prevent whipping) and topped by a copper sheet. Concealed clerestory windows are to be built into the intersections of the paraboloids. Consulting engineers for the project are A. J. and J. D. Harris, of London; calculations for the roof were done on the computer in the civil engineering department of Southampton University.

The layout is such that visitors will pass through a foyer and arrive on a central platform within a central well formed by pierced gallery floors. From the platform, visitors will have only a half storey climb to and from the two lower floors and will be able to see all the galleries. The curtain walling will be of opaque glass and the exhibits artificially lit. The Institute provides a permanent exhibition of the Commonwealth countries, but the minimum internal arrangements provided will enable the displays to be modified as circumstances warrant. The main block will appear as a copper-green "tent", set among the trees of Holland Park where it is to be located. The architects are Robert Matthew and Johnson-Marshall of London.

Fire Protection by Asbestos

The most recent booklet from Turners Asbestos Cement Company Limited, of Trafford Park, Manchester, is *Fire Protection of Structures*. It is a brief interpretation (36 pages) of the byelaws in relation to the use of asbestos and asbestos cement materials. Copies can be had from the company on request.

The illustrations show the various fire tests that are normally carried out at the Fire Research Station on different types of structures such as floors, walls and columns. Sketches and tables indicate the fire protection obtained with different thicknesses of asbestos as coverings to structural members or as insulation board in partitions. The booklet is a revision of an earlier publication and has additional paragraphs on the combustibility test, external fire exposure roof test and corroglaze sheets.

Work Well in Hand on Rajasthan Canal

Construction is now well in hand for the Rajasthan canal system, near Hanumangarh, in India. The canal is 425 miles long and when it is finished will have 2,000 miles of subsidiary distributing canals. It is described as the longest in the world. Masonry work has started and kilns have been erected to fire the bricks to line the canal.

On completion, the system will irrigate some 1·7 million acres, and, in consequence, this area is expected to yield an additional two million tons of food grains per annum. The canal will be fed from the Govindsagar Reservoir, which has been created by the Bhakra Dam in Punjab. Water is due to begin flowing into the system in 1960 or 1961. The total cost of the undertaking is expected to be Rs. 1,500 million, and the money is being found by a loan to the Rajasthan Government from the Central Government.

£3·2 Million Contract for Power Station

Richard Costain have been awarded a contract valued at £3·2 million for the construction work at West Thurrock power station, near Grays, Essex. The contract includes foundations and superstructures of the main buildings, administration offices and other buildings. An alternative method of building the barrel vault roof of the turbine house was submitted by Costains and accepted, permitting a reduction in the tender price.

The station will have a capacity of 1,000 MW and consultants for the civil work are Sir Alexander Gibb and Partners.

Piles with Helically Welded Casings

The British Steel Piling Company Limited have installed a Driam machine at their works near Ipswich for producing steel pipes by winding strip helically and welding. The submerged arc process is used and the seam made by two welding heads, one working inside, the other outside the tube. The heaviest tube listed is 28 in in diameter of $\frac{3}{8}$ in material, weighing 113·6 lb per ft run.

The company are using these pipes for the casings of piles. After driving, the casings are filled with concrete which is placed under good conditions. The tubes are easily handled, and can be shortened or extended as necessary. They are also easily inspected after driving.

The company have also built a new pile driving plant, with a tubular frame and equipped with a McKiernan-Terry hammer, in which all the motions of raking, rotating, walking and leader adjustment are hydraulically controlled.

Mortars for Brickwork and External Rendering

The Tunnel Portland Cement Company have redesigned their Masonry cement to permit (without sacrificing strength) the use of leaner mixes than hitherto for brickwork, external renderings and internal plasters. A leaflet issued by the company gives recommended mixes for different uses when well-graded sands complying with British Standards are used. A more comprehensive booklet on masonry cement is being prepared and will shortly be available on request from the company at 105 Piccadilly, London, W1.

European Committee for Construction Equipment

The recently formed European Committee for Construction Equipment (ECCE) had its first meeting in Paris recently and the following countries were represented: Belgium, France, Germany, Italy, Sweden, Switzerland and the United Kingdom. The first officers appointed were: president, Mr. G. A. Hannah (Pegson Limited); vice-presidents, Mr. W. Cordes (Menck und Hambrock, GmbH) and M. A. Pommier (Ateliers d'Ermont). The committee has among its objectives the preparation of agreed standards, specifications, testing methods and procedures and terms of work.

Aerial Survey in Iran

Hunting Aerosurveys Limited are carrying out a survey for the Iranian Oil Exploration and Producing Company in connection with the definition of the boundary of the consortium's oil agreement with Iran. The perimeter of territory totals 2,000 miles. Ground controls are being established prior to photogrammetric mapping.

Volta River Preliminary Works Contract

Parkinson Howard Limited (a group comprising Sir Lindsay Parkinson and John Howard) have obtained the contract for the access roads for the Volta river project preliminary works. The contract comprises 2 miles of road widening, 9 miles of new road to trunk road standards, 3 miles of housing layout and 4 miles of dam site construction roads. The contract was obtained from Kaiser Engineers and Contractors Incorporated; and the consulting engineers are Sir William Halcrow and Partners of London. The value of the contract is £420,000 and the work is to be completed in 9 months.

Epoxy Resin Asphalt for Runways

Last year 150,000 sq. ft of apron at San Francisco international airport were paved with Epon asphalt concrete and service has shown that the paving stands up well to jet aircraft operation, having resistance to both loading and to fuel spillings. The material is a Shell Oil Company product which uses a blending of conventional asphalt with Epon resin (an epoxy resin developed by the company). It can be placed as a thin overlay of less than $\frac{1}{2}$ in in thickness and is easily laid by conventional paving machines and rollers.

MOBILE POWER STATION FOR RUSSIA

In the face of severe Continental competition, Ruston and Hornsby Limited of Lincoln won an order to supply Russia with a mobile power station, which they have now despatched.

This British-built plant (the first of its kind) is powered by a Ruston Mark TA 1,000 kW gas turbine, the first British industrial gas turbine to be exported to the USSR. Mounted on a specially constructed railway wagon, the plant will be used as an electric power source for semi-isolated civil construction sites (where power distribution lines are not available) and for small townships temporarily cut off from electric supplies by severe weather.

The gas turbine burns oil or natural gas fuel and drives a 6·6 kV 3 phase alternator. It was designed to operate in extreme climatic conditions, with air temperatures as low as − 40° C. This type of gas turbine is now in use throughout the world, both on land and sea, for a variety of purposes ranging from auxiliary power supply on board a naval vessel to pumping power for oil pipelines. Outside the United States, Ruston and Hornsby is the only company manufacturing gas turbines of this type on a batch production scale. Since commencing production on this scale they have sold more than 100 gas turbines of the TA type.

The complete rail wagon assembly (with gas turbine, electrical equipment and auxiliary plant) weighs about 65 tons and measures approximately 66 ft by 14 ft by 10 ft. The weight of the railway wagon accounts for about half the total assembly weight, and the chassis for this 30 ton unit was specially constructed in Belgium and shipped to Lincoln. The bodywork of the wagon and the remaining equipment (apart from the electrical and compressor gear, and minor ancillary equipment) was designed and manufactured by Rustons.

When the wagon is stationary and the power plant operating, the sides of the wagon body can be opened upwards to form flaps, as illustrated, to facilitate operation and allow maintenance work to be carried out. Strip lighting (8) is used inside to provide uniform illumination when the body flaps are down or when the plant is operating at night.

Arrangement

Divided into three main sections, the mobile power plant is entirely self-contained and may be transported as required.

The first section (shown at the right-hand end of the wagon) houses the mechanical auxiliary equipment which includes the fuel supply system with a 1,000 gallon oil fuel tank (7), and a diesel-driven gas compressor (5). When the turbine is operating on natural gas (which is piped from an external source since space restrictions preclude the storage of this fuel) this separate compressor is necessary to bring the incoming gas to a suitable working pressure. The two-stage reciprocating compressor is driven by a Ruston 6YDA air-cooled 110 b.h.p. engine (6) from the company's most recent range of air-cooled diesels and represents the largest air-cooled engine they manufacture. An air-cooled diesel was necessary for this duty because such an engine is not handicapped by extremely low temperatures as is a water-cooled unit.

The centre-section of the wagon contains the heart of the power station. Here the Ruston TA gas turbine (1) is installed, together with the alternator (2) that it drives. The gas turbine weighs about 6 tons (less than one-tenth the complete station) and occupies just over one-fifth the wagon's total length. This compact and relatively lightweight power unit may be started from cold in a matter of seconds, or immediately shut down from full-load. This is made possible by the "kinematic" design which allows free thermal expansion and contraction, while maintaining alignment during heating or cooling.

Some details of the Ruston TA gas turbine, a simple, open-cycle type with free turbine, now follow:

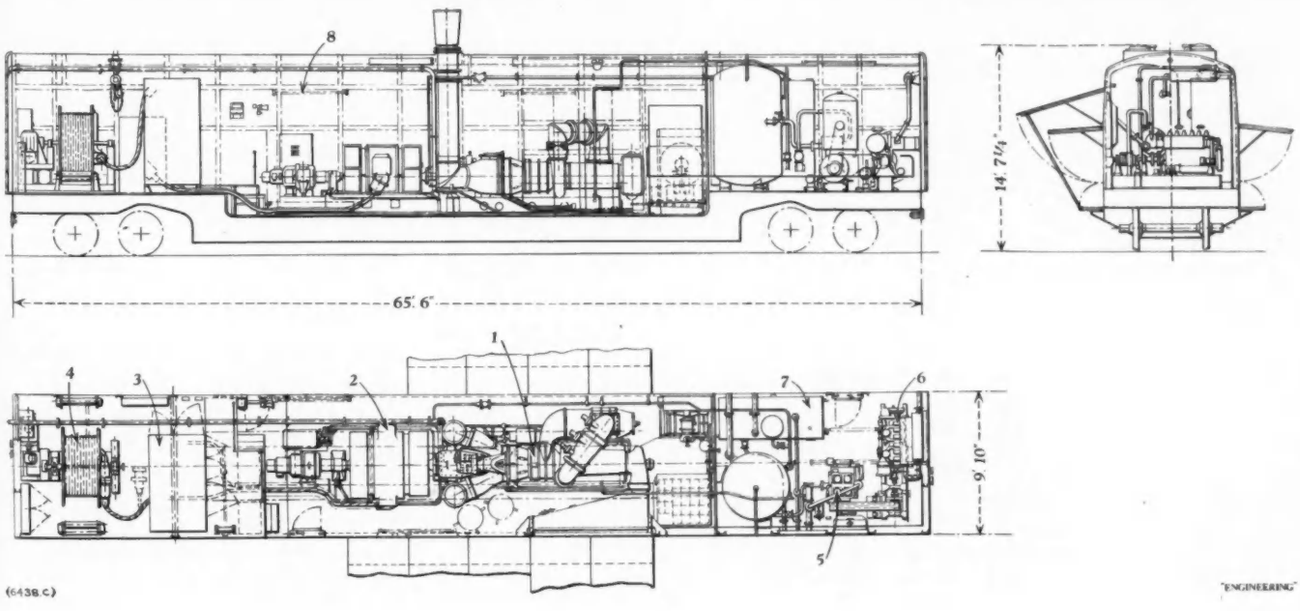
The TA gas turbine

Air enters the 13 stage compressor under atmospheric conditions, the inter-action of the succeeding rows of rotor and stator blades producing a steady increase of pressure. On delivery from the compressor, the air is heated to maximum temperature and greatly increased in

Mobile power station leaves for USSR (left).

The Russians have a word for Ruston (right).

Layout of the wagon noting installation details (below).



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"ENGINEERING"

volume by burning liquid or gaseous fuel, a process which takes place in the combustion chamber with minimum loss in pressure. High temperature gases from the combustion chamber are partially expanded through the compressor turbine, which is directly coupled to the compressor. This unit forms a gas generator, the output of which is varied automatically according to the load. The gases are finally expanded to atmospheric pressure in the power turbine, which is independent of the gas generator rotor system, but coupled through reduction gearing with the driven machine.

Gas turbine specification

Rating.—Normal continuous rating, in an ambient temperature of 80° F: 1,260 b.h.p.

Output shaft speeds.—Standard output shaft speeds: 1,200, 1,500, 1,800 and 6,000 r.p.m.

Compressor.—13 stage axial flow.

Turbines.—Both the compressor and power turbines are 2 stage axial flow, the rotors being cooled by air fed from the compressor.

Combustion chamber.—Single all-metal, elbow type, combustion chamber, equipped with burners suitable for liquid and gaseous fuels.

Starting system.—24 volt d.c. starter motor engaging with the front end of the compressor shaft. Starting is carried out by the operation of a single hand wheel which controls the fuel supply and the operational sequence of the electrical circuits during the starting cycle.

Bed-frame.—Fabricated steel. The bed-frame also forms the lubricating oil reservoir.

Control system.—Hydraulic control system supplied with servo-operating oil from the engine lubrication system. Governor of standard counter-weight type fitted. Control cubicle also contains turbine instruments and controls, including the starting control.

Protective devices.—Automatic devices for protection against overspeed, loss of lubricating oil pressure and excessive gas temperature.

The third section houses the electrical equipment:—switchboard, voltage and current transformers, circuit-breakers and a motor-operated reeling drum (4) which accommodates 100 yards of armoured, flexible 3 core cable capable of carrying the 1,000 kW 6·6 kV supply. The electrical power take-off via this drum may be obtained from either side of the wagon through suitable outlets in the wagon body so that the cable can be paid out at will.

All the electrical equipment, alternator with exciter and pilot exciter and control gear was supplied by Crompton Parkinson Limited. A brief description follows:—

Electrical equipment

The alternator has an output of 1,250 kVA, 0·8 power factor, 6,600 volts, 3 phase, 50 cycles 1,500 r.p.m. It is a filter ventilated machine, there being an aerofoil pattern fan at each end of the rotor. Each fan draws in air through two Vokes filters mounted in the end covers, and this air circulates through the windings and is exhausted through an opening at the top of the stator frame. The Vokes air filter for the main exciter is mounted in the bed plate underneath the commutator endshield. The pilot exciter is totally enclosed.

The control gear consists of two fixed steel cubicles carried on anti-vibration mountings and is designed for both single and parallel running. The two voltmeters, synchroscope and frequency meter are mounted on a fixed steel panel immediately above the neutral earthing switch.

Protection comprises a PBO over-current relay and a separate relay to give restricted earth fault protection. The field suppression equipment is mounted inside the exciter cubicle, which also houses a 7½ kVA transformer which provides power for the auxiliaries. Because this transformer is required to be energised whenever the machine is running, irrespective of whether the main circuit breaker is open or closed, it is fed directly from the incoming terminals and is protected by HRC fuses and included in the zone of restricted earth fault protection.

The automatic voltage regulator (by Brown Boveri) can maintain the voltage within plus or minus 0·75 per cent.

PROBABILITY OF SERVICE FAILURES

Determination from Strength Values

By I. J. SOMERVAILLE

The University of New South Wales

A method is described for determining the probability of failure in service of a structural component, given a limited number of experimentally observed strength values. The method may be applied in any circumstance in which it is known that the distribution of strength, or of some function of loading at failure, of the population conforms to the normal distribution.

Failure of a load-carrying component occurs when the loading to which it is subjected exceeds the strength of the component. The strength of any one component for a particular type of loading is a unique value, but the individuals in a group of nominally identical components can be expected to differ in strength. For a given type of loading and definition of failure it is possible to determine by test the strength of one or more individuals, and thus obtain approximate information about the distribution of strength of the population of nominally identical components. In this article it is supposed that tests are made on a limited number of samples from a population whose strength is known to be normally distributed. It is shown how the probability of other untested components failing in service at a specified loading can be found from the observed values of the strength of the sample components.

This problem has been discussed before[1, 2] and a solution given by confidence limit methods. In effect, these methods give, for a specified loading, a boundary value of the probability of failure such that the probability of the boundary value being exceeded is an arbitrarily chosen small value. The method described here gives an unqualified value for the probability of failure and it is considered that this method is more convenient for many practical applications.

Probability of Failure in Terms of Normal Distribution Parameters

It is convenient to regard any component as a single sample from an infinite population of possible components made by the same production process. Let it be supposed that the loading, w, is so defined that the strength, x, of the members of the population is normally distributed. A normal distribution of strength is completely specified by two parameters, μ the mean strength, and σ the standard deviation of strength.

The cumulative frequency distribution of the standardised normal variate, $u = \dfrac{x-\mu}{\sigma}$, gives the probability that the value of u for a random sample will be less than a specified value. Symbolically,

$$\mathrm{P}\{u < u_\theta\} = \theta \quad . \quad . \quad (1)$$

where u_θ and θ are corresponding values of u and cumulative frequency. Tables of these values are readily available.

If follows that,

$$\mathrm{P}\{x < \mu + u_\theta\,\sigma\} = \theta \; . \quad . \quad (2)$$

If a randomly selected component from this population is subjected to a load,

$$w = \mu + u_\theta\,\sigma \quad . \quad . \quad (3)$$

$$\mathrm{P}\{x < w\} = \theta. \quad . \quad . \quad (4)$$

In other words, the probability of failure is θ. This probability of failure, designated θ, determined in terms of the parameters of the strength distribution of the population, is subsequently called the " population probability of failure."

Probability of Failure of a Single Component in Terms of Observed Strength Values

A limited number of determinations of the strength of random components does not yield sufficiently precise estimates of the parameters of the strength distribution to permit using the above equations to determine the probability of failure. In some cases the coefficient of variation and hence the standard deviation, may be known with sufficient precision from the results of many tests on samples of similar types of components subjected to similar types of loading, but this is not always so. Therefore, two problems are considered in this section: firstly the determination of the probability of failure from observed values of the strength of random samples, when the standard deviation is known previously, and secondly the determination of the probability of failure in terms of observed strength values alone.

Case 1—Standard Deviation Known.—Values of strength, x, are obtained by tests on n random components. Let $\bar{x}$, and x_{n+1} be respectively the observed mean strength of the sample of n components, and the strength of one additional untested component. Both these variates are normally distributed with a mean value μ, the standard deviations being $\sigma/\sqrt{n}$ and σ respectively. It follows that the variate $(x_{n+1} - \bar{x})$ is also normally distributed, with a zero mean and standard deviation $\sqrt{1 + \frac{1}{n}}\,\sigma$. The standardised variate is

$$u = (x_{n+1} - \bar{x}) \Big/ \left(1 + \frac{1}{n}\right)^{\frac{1}{2}} \sigma \quad . \quad (5)$$

If

$$\mathrm{P}\{u < u_\mathrm{P}\} = \mathrm{P} \; . \quad . \quad . \quad . \quad (6)$$

$$\mathrm{P}\left\{x_{n+1} < \bar{x} + u_\mathrm{P}\left(1 + \frac{1}{n}\right)^{\frac{1}{2}} \sigma\right\} = \mathrm{P} \quad (7)$$

Therefore, at a service load

$$w = \bar{x} + u_\mathrm{P}\left(1 + \frac{1}{n}\right)^{\frac{1}{2}} \sigma \quad . \quad . \quad (8)$$

the probability of failure is P.

This means that in the long run of different cases in which the service load, w, corresponds to a particular value of P in equation (8), the proportion of failures in the first untested component is P. The same statement is seen to be true also of the second, third and fourth, etc., untested components. Thus equation (8) provides a means of determining the probability of failure of any single random component considered by itself from observed values of the strength of other random samples from the same normally distributed population.

Case 2—Standard Deviation Unknown.—Values of strength, x, are determined from tests on n

random components, and from these the sample mean $\bar{x}$ and the sample standard deviation

$$s = [\sum_{1}^{n} (x - \bar{x})^2 / (n - 1)]^{\frac{1}{2}} \quad . \quad (9)$$

are determined. Consider the variate

$$t = (x_{n+1} - \bar{x}) \Big/ \left(1 + \frac{1}{n}\right)^{\frac{1}{2}} s \quad . \quad (10)$$

The variate $(x_{n+1} - \bar{x}) \Big/ \left(1 + \frac{1}{n}\right)^{\frac{1}{2}}$ is normally distributed with zero mean and standard deviation σ. The variate, t, is thus the ratio of the deviation of a normally distributed variate from its mean and s, an independent estimate of its standard deviation. It thus conforms to Student's distribution for the number of degrees of freedom in the estimate s, that is, $(n - 1)$ degrees of freedom.

The cumulative distribution function of Student's distribution for $(n - 1)$ degrees of freedom gives corresponding values of t_P and P in

$$\mathrm{P}\{ t < t_P \} = \mathrm{P} \quad . \quad . \quad (11)$$

It follows that,

$$\mathrm{P}\left\{ x_{n+1} < \bar{x} + t_P \left(1 + \frac{1}{n}\right)^{\frac{1}{2}} s \right\} = \mathrm{P} \quad (12)$$

Therefore, at a service load,

$$w = \bar{x} + t_P \left(1 + \frac{1}{n}\right)^{\frac{1}{2}} s \quad . \quad (13)$$

the probability of failure in the first untested component, or in any other untested component, considered by itself, is P.

By use of equations (8) or (13) it is possible to determine a working load for a specified probability of failure, or solve the inverse problem, provided the corresponding values of u_P, t_P and P are known. Extensive tables of t_P and P are not readily available, so to facilitate such calculations a chart has been drawn of the factor $t_P \left(1 + \frac{1}{n}\right)^{\frac{1}{2}}$ for various values of n, using logarithmic scales. A single curve for the factor $u_P \left(1 + \frac{1}{n}\right)^{\frac{1}{2}}$, for $n = 1$, is also shown. When $n = \infty$ the curves for each factor are identical.

The Probability of Failure in a Set of Nominally Identical Components

Consider a set of m nominally identical components subjected to a service load, w, such that the probability of failure determined by equation (8) or (13) is P. In any such set the behaviour of the individual components is further connected by the fact that the unknown population probability of failure is the same for each component; thus the probabilities P are not independent.

Let the probabilities of one, two or three, etc., failures occurring in a set of m components be P_1, P_2, P_3, etc., and the probability of failure in individual components be P, as determined above. Consideration of the mean proportion of failures in sets of m, when the number of different sets with separately determined P becomes very large, shows that

$$\mathrm{P}_1 + 2\mathrm{P}_2 + 3\mathrm{P}_3 + \ldots + m\mathrm{P}_m - m\mathrm{P} \quad (14)$$

Thus the probability of failure occurring in a set of m components

$$\mathrm{P}_1 + \mathrm{P}_2 + \mathrm{P}_3 + \ldots + \mathrm{P}_m < m\mathrm{P} \quad (15)$$

For values of $m\mathrm{P} \ll 1$, it is to be expected that $\mathrm{P}_1 \geqslant \mathrm{P}_2 \geqslant \mathrm{P}_3$, and consequently

$$\mathrm{P}_1 + \mathrm{P}_2 + \mathrm{P}_3 + \ldots + \mathrm{P}_m \sim m\mathrm{P} \quad (16)$$

The Probability of Failure of a Structure with Fixed Partition of Load between Components

Consider a structure of nominally different components in which the loads carried by the individual components are known, and are independent of any deformations which may take place, where the probabilities of failure, P_1, P_2, P_3, etc., of the individual components has been separately determined by test as above. If the structure fails when any one component fails, these probabilities are independent. The probability of failure of the structure is given by:

$$\mathrm{P}_s = 1 - (1 - \mathrm{P}_1)(1 - \mathrm{P}_2), \text{ etc.} \quad (17)$$

where P_1, P_2, P_3, etc., are the probabilities of failure of the different components. If the individual probabilities are so small that their products may be neglected,

$$\mathrm{P}_s = \mathrm{P}_1 + \mathrm{P}_2 + \mathrm{P}_3 + \quad \text{etc.} \quad . \quad . \quad (18)$$

Example

While the application of the method described presents no difficulties it is thought worth while to examine a particular problem as it illustrates points not yet considered. The problem considered is a hypothetical example examined by Kennedy.[1] He supposes that fatigue tests are carried out on four sections of an aeroplane wing, seven tests on each, to determine the fatigue life of each section under simulated service conditions. He then uses the fact that the logarithm of the number of load cycles before fatigue failure appears to be normally distributed, and estimates the probability of failure of the wing structure as a whole for any given number of operational hours, using confidence limit methods.

The logarithm of the number of load cycles to failure is taken here as x and the logarithm of the number of cycles in the working life as w. From Kennedy's example, for the centre section $\bar{x} = 5{\cdot}659$ and $s = 0{\cdot}082$. For an operational life of 10,000 hours (160,000 load cycles), $w = 5{\cdot}204$.

$$\frac{w - \bar{x}}{s} = \frac{0{\cdot}455}{0{\cdot}082} = 5{\cdot}5$$

and $\quad t_p = 5{\cdot}2$

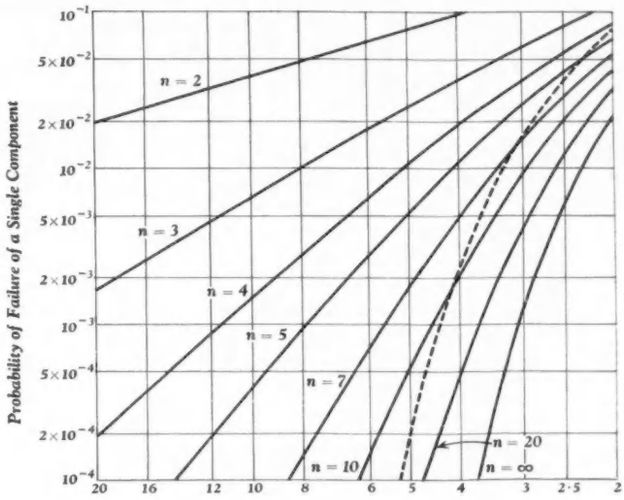
Hence $\mathrm{P} = 0{\cdot}0010$. This result is to be compared with the value of $0{\cdot}0003$ at the 90 per cent confidence level obtained by Kennedy. Discrepancies of the same order are found for the other wing sections.

A difference between the values is of course to be expected, but at first sight it is a little surprising to find the estimate based on a confidence coefficient is so much less conservative in this case. Kennedy uses a 90 per cent confidence limit, so that there is a 90 per cent probability that the population probability of failure in any one case is less than $0{\cdot}0003$. In the long run of such determinations, however, in 10 per cent of the cases θ will have a value in excess of $0{\cdot}0003$, and in some cases so much in excess that the mean value of θ, which is in fact the value of P, is $0{\cdot}0010$.

The comparison reveals a weakness of the confidence limit method, which is that it is necessary to adopt a value of confidence coefficient appropriate to the probability of failure concerned if misleading indications of long run failure rates are to be avoided. In this particular case a confidence coefficient of 99 per cent would seem to be more appropriate.

Having determined probabilities of failure for the various components for a given confidence coefficient, Kennedy proceeds to establish the probability of failure of the wing using the method given above. While there is practical justification for making this step it must be observed that the resulting value cannot be allotted any precise significance in terms of confidence coefficients.

For example consider the case of two components with probabilities of failure θ_1, θ_2 at the 90 per cent confidence level. If failure may take place through failure of either component,



it is found that the probability of failure is $\theta_1 + \theta_2$ with an unknown confidence coefficient between 81 per cent and 99 per cent. As the number of components increases the uncertainty about the confidence level must increase.

CONCLUSION

A method has been given for estimating the probability of failure at a service load in a random sample from a population of normally distributed strength. It has been shown that the probability of failure in a set of random samples can be conservatively estimated, but an exact solution has not been given. It will be noted that the principle involved, that of finding the probability of failure directly in terms of observed values, can possibly be applied to distributions other than normal. A particular problem which might be attacked is the determination of the distribution of $x_{1,m} - \bar{x}$, where $x_{1,m}$ is the smallest strength value in a set of m random components from a normal population. A solution of this distribution, by numerical methods if necessary, gives the precise evaluation of the probability of failure among m components from a normal population in terms of observed values.

The method proposed can also be applied in cases where not the strength but the load is a normal variate, or where both strength and load are normal variates. An example of the former is where the logarithm of the peak annual flow of a river is believed to be normally distributed.

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[1] A. P. Kennedy, *Journ. of the Royal Aero. Soc.*, Vol. 58 (1954).

[2] J. A. Pope, B. K. Foster and N. T. Bloomer, ENGINEERING, Vol. 184, 23 and 30 August (1957).

[3] P. A. P. Moran, Trans. Amer. Geophysical Union, Vol. 38, 4, 1957.

GUILLOTINE

For Cellophane Foil, or Hardboard

THE Giant range of guillotines is designed for use in paper mills or to cut cellophane, metal foil, linoleum, hardboard or like materials.

There are at present two models, one with a cut of 75 in and the other with one of 85 in. Larger sizes are intended. The machines are fitted with electronic controls which afford infinitely variable spacing and fine trim cuts guaranteed to within 0·002 in. Machines with push button controls can also be supplied.

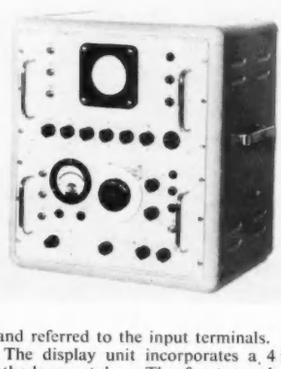
Automatic cutting is governed by the settings on the spacing bar at the top of the machine which is traversed by an illuminated cursor that detects the marking flags. These have individual micrometer adjustment and six spacing bars can be on the carrier at any one time, the carrier being rotated to bring the one required into position. It is these settings that control the movements of the power-operated back gauge.

The height of the working surface of the table is 36 in above ground level, and in the larger machine the table has an area of 78 sq. ft. Hydraulic elevating tables can be supplied as extras. Both front and back operating tables are served by an air jet system for stock handling. It is claimed that this arrangement simplifies movement.

The material is held by a hydraulically operated clamp which has a total load variable up to 12,000 lb. The back gauge is driven by a 2 h.p. motor through a precision lead screw synchronised with the spacing control. It can also be operated by push buttons at the front. Cutting knives are available with various bevels to suit the material being cut. *Furnival and Company Limited, Waterloo Engineering Works, Stockport, Cheshire.*

SPECTRUM ANALYSER

Audio and Supersonic Frequencies



THE type 190 spectrum analyser can be used at audio and supersonic frequencies to analyse the spectrum of a complex or simple signal. The range of the standard instrument is from 500 c/s to 90 kc/s.

Operating on the superheterodyne principle with a highly selective flat topped IF response which, in the standard instrument is 70 c/s wide, this instrument enables single frequency, or alternatively noise signals, to be measured accurately at input levels down to 1 microvolt, or even less. An oscillographic panoramic display allows the general nature of any spectrum within the frequency range of the equipment to be examined rapidly.

Input signal components in the range from 0·1 V to 1 microvolt rms in a 70 c/s band can be measured with an accuracy of ± 2 db at frequencies from 500 c/s to 90 kc/s. The inherent noise level of the equipment corresponds to approximately 0·2 microvolt in a 70 c/s band referred to the input terminals.

The display unit incorporates a 4 in cathode ray tube. The front panel is provided with a viewing hood and camera mount. Both *x* and *y* plates are driven symmetrically by paraphase amplifiers. The time base is derived from the generator controlling the sweep oscillator or alternatively from a built-in free running saw tooth generator. *James Scott and Company (Electrical Engineers) Limited, 68 Brockville Road, Carntyne Trading Estate, Glasgow, E2.*

GANTRY CRANE

Light Weight Unit Made to Measure

FOR those who want a light weight gantry crane the illustration shows a possibility.

The gantry was built by two men in the space of four hours using standard Dexion slotted angle sections. It has a safe working load of one ton and is equipped with a hand operated hoist of the same capacity.

As will be seen the gantry is fully mobile, running on castors of any make, suitable for the loading and operating conditions. The full working load can be on the hook when the gantry is being moved. The castors should have a safe load capacity of 1,000 lb each to carry the designed load of 1 ton. For ease of handling swivel castors are used.

As built, the height of the hoist hook is approximately 7 ft fully raised and the inside clearance of the gantry is 6 ft. The assembly was carried out with ⅜ in bolts, as a rule using only one at each connection. Slight modifications to the design would make the gantry stronger for use with heavier or electrically operated hoists. *Dexion Limited, Beresford Avenue, Stonebridge Park, Wembley, Middlesex.*

PRESS BRAKES

Range covers from 20 to 80 tons pressure

THERE are nine machines in the range of Besco-Truebend press brakes with capacities from 72 in by 16 s.w.g. by 20 tons up to 120 in by ¼ in by 80 tons.

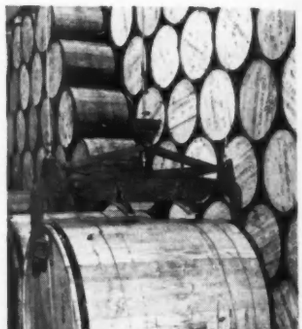
The brakes are built from heavy rolled steel plates, welded and bolted together to give rigid strength and eliminate deflection. Deep gaps from 6 in to 10 in in the side frames permit the forming of plates longer than the bed in more than one operation. The bed is wide and machined full length; dovetailed slots front and rear will accommodate die setting plates and gauges. Tool height setting is by ram adjustment. In the case of the 20 and 40 ton machines, this adjustment is by hand-operated worm and worm wheel gear reduction. The remaining five larger machines have the ram adjustment by motor through worm and worm wheel. A setting scale and indicator is provided on all machines.

The machines are arranged for V-rope motor drive through heavy spur gearing, enclosed in a box running in oil. The balanced flywheel, which is machined all over, incorporates a disc-type clutch, operated by a full length treadle through a series of levers, giving light but positive control to the machine. The brake is connected to the treadle mechanism allowing the operator to inch the ram.

A band brake is fitted to each of the 20 and 40 ton machines, while the 60 and 80 ton models have shoe brakes. Control of the main drive motor and auxiliary ram adjusting motor, when fitted, is by flush-mounted push button stations on a contactor box. Single shot lubrication system is fitted and steel guards cover the gears, drive and crankshaft. *F. J. Edwards Limited, 359-361 Euston Road, London, NW1.*

LIFTING TONGS

Developed for Close Stacking



FOR the close stacking of barrels and cases a special form of the Somers automatic lifting tongs has been developed.

The design was originally intended for handling barrels or cases of tobacco measuring 3 ft 10 in in length, stacked with their axes parallel. To prevent any rotation of the load two wires were attached to the tongs, one at each end, from self-reeling drums mounted on either side of the travelling carriage of the cranes. Pendulum swing was not found to be sufficient to be a trouble.

The design of the tongs has been such that a side clearance of only 4 in is required. This still leaves a large safety factor when lifting 10 cwt casks. Basically the jaws consist of rectangular steel plates in which are inserted detachable studs made from toughened steel with sharpened contact points. It has been found that these do not cause damage to the wood of the casks or cases. The studs can be replaced at any time when the points become blunted, the replacement taking only a few moments.

Using the prototype tongs, stacks up to 30 ft high have been made without the assistance of slingers. It is said that the final height of the stack is only limited by the crane clearance. *Walter Somers (Materials Handling) Limited, Halesowen, nr. Birmingham.*

DEW POINT METER

For Temperatures down to −80°F

THE Alnor Dewpointer is now being marketed in this country.

The meter is portable and self-contained, requires no coolant, and has a measuring range from − 80° F to room temperature, or from 0·0015 per cent to about 2·75 per cent water vapour by volume. The measurements are made by compressing a sample of the gas to a pressure at which, on sudden release a mist is formed, the temperature of the dew point then being calculated from the temperature and pressure ratio before expansion.

The gas to be checked is drawn through the meter into an observation chamber with a hand pump, the chamber being fitted with a purging valve to allow a previous gas sample to be cleared. The chamber is illuminated to make the mist easily visible. The pump is designed to prevent the slightest trace of moisture being introduced into the chamber by the wiping action along its barrel. The meter is fitted with a sensitive thermometer mounted in clear Perspex and a pressure ratio gauge to give quick direct readings of the ratio of atmospheric pressure and observation chamber pressure. The meter can be battery operated or connected to the mains. *Electric Resistance Furnace Company Limited, Netherby, Queens Road, Weybridge, Surrey.*

DIGITAL VOLTMETER

Four Figure Readings of High Accuracy

THE Solartron type 902 digital voltmeter gives four figure digital reading to an accuracy of 0·1 per cent.

The instrument has been designed for monitoring physical quantities converted to voltages. It is a development of the type 901 which had three figures only. Like the 901 it is fully transistorised and is light in weight and robust in construction.

The use of digital figures allows far greater accuracy than is possible on dials or recording charts. Errors accidentally introduced by parallax and statically or magnetically false representation are also avoided. The figures are 1 in high and can be read in broad daylight across a room.

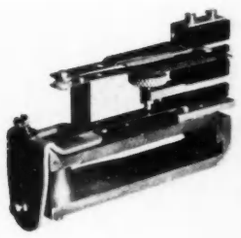
The figures are back projected on to the front display as bright digits against a black (negative polarity) or red (positive polarity) background, or the measured voltage may be isolated and earth referenced.

There are five voltage ranges with full scale deflections from 0·1599 V up to 1599 V, all reading to an accuracy of 0·1 per cent. The corresponding input impedances range from 100k ohms to 10M ohms. There are also two other voltage ranges with higher impedances (100M ohms) but lower accuracy, the full scale deflections being 100 V and 1,000 V and the accuracy of each to 0·5 per cent. The illuminated decimal point which appears on the reading is set by the range switch.

The instrument has a dead zone control for stabilising the readings on fluctuating inputs and the smoothing has up to 40 db common mode rejection of 50 c/s at the input. The range switch includes check zero and standardise positions. Provision is made for connection to a printer. *Solartron Electronic Group Limited, Thames Ditton, Surrey.*

BUSBAR RELAYS

For High Current D. C. Systems



THREE types of Londex relays are now available for indicating heavy currents flowing in busbars of d.c. systems. They can also be used for overload trips.

No conventional coil is employed as the yoke is made to fit round the busbar itself. Type BZ/SQ is for rectangular bars and BZ/R for bars circular in cross section. They can be installed without disturbing existing installations. Swedish iron is used for the yoke thereby avoiding residual magnetism.

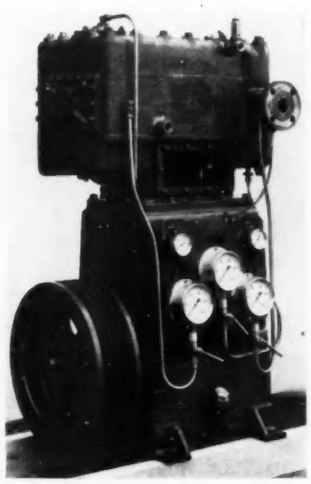
Each relay is provided with one set of normally open silver contacts, 6 mm in diameter, which are capable of handling up to 4A at 250 V a.c. An adjusting screw allows the operating current to be set at any point within the range of the type.

Both types of relay are available with a pneumatic damper if required, providing a delay of approximately ½ second to avoid operation by high transient currents. Type BZ/SQ is available in five sizes for currents up to 1,100 A and type BZ/R in three sizes up to 400 A.

The third of the new relays is polarised and designed to give indication of the occurrence of a backfire in high current mercury rectifier systems or for reversal of current generally. Like the other two, the iron circuit is a clamp that encloses the conductor and the standard model is capable of withstanding forward or reverse currents of 20,000 A. It will trip at a reverse current of 6,000 A having a rise time of $3{\cdot}6 \times 10^6$ A per sec, the speed of contact operation being less than 10 milliseconds. *Londex Limited, Anerley Works, 207 Anerley Road, London, SE20.*

AIR COMPRESSOR

Oil Free Supply for Servo Systems



A RECENT addition to the Williams and James range of oil free air compressors is a two stage double acting machine which will deliver 55 cu. ft per minute of free air at pressures up to 250 lb per sq. in.

The machine has a stroke of 4 in and the two bores are 5 in and 2½ in. The maximum rated speed is 900 r.p.m. and the minimum 250 r.p.m. When running at the maximum speed it will deliver 55 cu. ft of free air per minute at 250 lb per sq. in, or when at the minimum speed it will deliver 15·5 cu. ft per min at 100 lb per sq. in. In the first case the power absorbed is 28 h.p. and in the second 4 h.p.; both these figures assume that the drive is by V belt from a synchronous motor running at 1,500 r.p.m.

Lubrication of the crankcase is from a gear pump driven direct from the crankshaft. This section is divided from the compression chamber to ensure separation of the oil from air.

The pistons are stainless steel and are split to allow the removal of the carbon rings. The bores are chromium plated. The valves are of the plate type held in position by caps. An interstage cooler is fitted integrally with the cylinder head. *Williams and James (Engineers) Limited, Gloucester.*

FREIGHT LIFT

For Loading Aircraft Speedily

THE Short freight lift was initially designed for loading and unloading military aircraft at small aerodromes. It can be dismantled and carried in the aircraft itself from place to place.

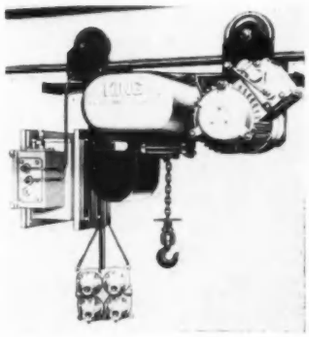
The lift consists of a platform measuring 14 ft by 12 ft suspended by cables from four corner posts, the complete unit being mounted on a foundation which itself has castor wheels to give positional adjustment. In operation the load is taken by pedestal feet. The construction is mainly of light alloy and honeycomb sections.

Power is provided by an electric motor centrally mounted on the base. It is geared to raise a load of 8,000 lb through 11½ ft in three minutes; loads up to 12,000 lb can be carried at a slower rate. The motor can be supplied from the 10 kW generator of a standard aircraft servicing trolley, and the operation can be controlled from either the top or the bottom.

The lift can be stopped at any height up to 11½ ft, so that it can be lined up to a lorry platform for example. For ground loading there is a 6 ft ramp hinged to the base. On the platform is a smaller ramp to make connection to the aircraft and another small ramp can be provided for connection with a lorry. When folded for stowage, the complete lift requires a space of 4 ft by 5 ft by 19 ft. Erection takes 20 minutes or less, and the lift can be dismantled in 10 minutes. Provision has been made for fitting ball and roller conveyors on the platform to handle heavy packages and a similar system can be fitted inside the aircraft. *Short Brothers and Harland Limited, Seaplane Works, Queens Island, Belfast, Northern Ireland.*

CHAIN BLOCKS

With Flameproof Electrical Equipment



IT is announced that the Marvex and Mammoth ranges of chain pulley blocks are now available with flameproof electrical equipment.

The lifting capacities range from 5 cwt to 10 tons and in spite of the necessary increase in dimensions caused by the requirements of the flameproof equipment, the overall unit has been kept compact by the arrangement of the various components.

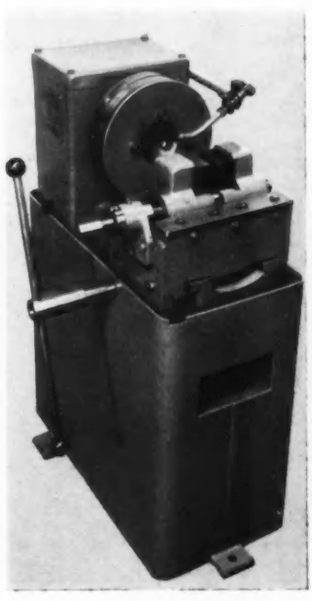
The electrical gear is mounted in flameproof enclosures which fully comply with the requirements of the Ministry of Fuel and Power, and carry the Buxton certificate for Groups II and III gases. Full precautions are taken to ensure that no sparks can be produced by impact.

With the exception of hook suspension, blocks may be arranged for normal suspension mountings, including hand pushed, hand geared and powered traverse trolleys. In most applications electric current can be supplied through festooned armoured cables suspended from a catenary wire or from supporting trolleys running on a light door track. Alternatively, reeling drums are available, while in certain cases trailing armoured cable with flameproof plugs and sockets can be used.

The flameproof electric chain pulley blocks have been introduced to meet the growing demands of industry where production processes frequently give rise to hazards from inflammable dusts fumes and gases. *Geo. W. King Limited, Stevenage, Hertfordshire.*

THREADING MACHINES

Capacity up to 4 inch pipe threads



THE Maiden type A threading machine has a capacity of from ¼ in to 2 in BSP or from ¼ in to 1½ in Whitworth bolts. A larger model goes up to 4 in BSP.

The machine is a motor driven cabinet mounted self-contained unit ready for installation. It is light enough to be readily transportable.

The headstock is cast solid with the bed to give rigidity, and the gearing is totally enclosed. The gear shafts run in replaceable bushes and have automatic lubrication.

The dies are of the adjustable chaser type and can be opened up to allow the work to be withdrawn.

The saddle is traversed on narrow guides by a pinion and inverted rack. The self-centring jaw vice is fitted with hardened steel grips and a coolant pump and equipment are incorporated. *Landis Machine-Maiden Limited, Hyde, Cheshire.*

HOW ROLLS-ROYCE MAKE OIL ENGINES

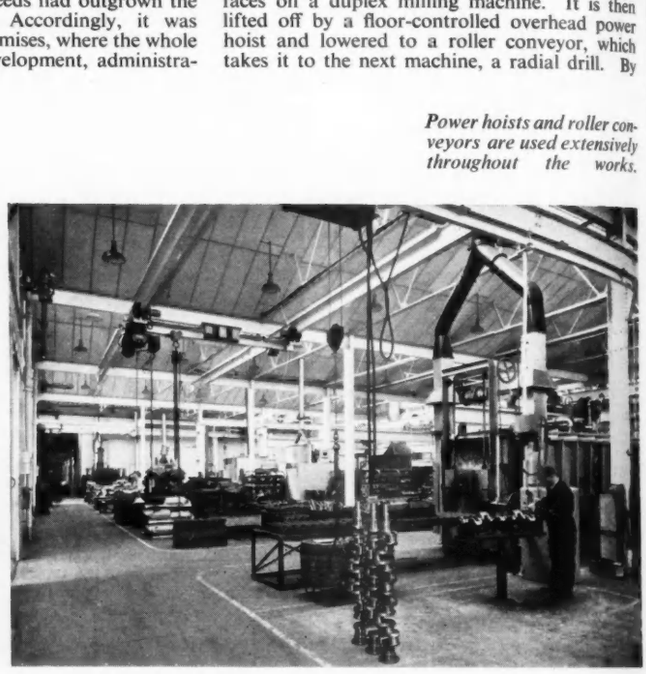
The name Rolls-Royce, associated for half a century with all that is best in motor cars, and equally celebrated for almost as long in the aero engine field, first appeared on diesel engines about ten years ago. To introduce a new product bearing a name which had come to be accepted as a hall mark of quality both in design and manufacture is not a task to be undertaken lightly, and more than 250,000 hours of development work, costing over £1 million, were behind the first production engine.

The basis of the development work was threefold; the range of engines should be economical in fuel consumption, reliable in operation, and easy to maintain. In addition, it was laid down that the work of development was to be continuous, the introduction of a new range of engines being regarded as only a beginning and not an end in itself. In this, of course, the oil engine division was following the precedent set by the motor car and aero engine divisions.

On the basis of the development work carried out, Rolls-Royce introduced a rationalised range of oil engines in four, six and eight cylinder models, with power outputs from 70 to 700 b.h.p.

Line production methods are applied wherever practicable to Rolls-Royce oil engine parts. The cylinder block line is shown here.

Power hoists and roller conveyors are used extensively throughout the works.



RATIONALISED RANGE

The basic engine is the six cylinder supercharged type, with bore and stroke of 5½ in and 6 in respectively, with direct injection into an open type combustion chamber by monobloc pump and mechanical or hydraulic two-speed or all-speed governor. The crankcase is so designed that the flywheel housing can be fitted to either end, and the exhaust system, supercharger (where applicable), filters and other externally mounted units can be fitted to the left hand or right hand side of the engine to suit particular installations. No chains are used, the drives being by means of ground gears. Normal starting is electric, but air, inertia or hydraulic starters can be fitted. Power take-off up to full engine power is available from the front end of the crankshaft, and other take-off points, with lower outputs, can be provided.

The majority of wearing parts are common to the whole range of four, six and eight cylinder engines, which retains the 5⅛ in and 6 in bore and stroke throughout, and can be supplied unsupercharged, supercharged by means of a Root's type positive displacement blower, or turbocharged by an inward flow exhaust turbine. In addition, the engines are available in normal vertical form, right or left hand; in horizontal form for underfloor installations; coupled in pairs by means of a gearbox; as marine variants with a wide choice of gearboxes, and as self-contained power packs. All the engines are designed to operate efficiently in any part of the world, being adequately cooled for use in the tropics, and capable of starting readily, without special equipment, at temperatures down to 9° of frost. With starting aids of the normal type, the engines will start in temperatures down to 97° of frost.

CENTRALISED MANUFACTURE

Manufacture of Rolls-Royce oil engines started at the company's Derby works, some of the component parts being made at other Rolls-Royce plants for final assembly at Derby, but by 1956 production needs had outgrown the facilities then available. Accordingly, it was decided to acquire new premises, where the whole of the manufacturing, development, administrative and commercial work could be carried on under one roof. The large modern factory of Sentinel (Shrewsbury) Limited was therefore taken over and here, on a site of 17 acres, with over half a million sq. ft of buildings and a considerable area available for expansion, the entire oil engine division was installed in 1957/8.

Complicated planning was necessary in order to move the production plant, modernise and re-arrange the equipment at Shrewsbury where necessary, and at the same time maintain production of engines. The move was carried out one department at a time, and was completed by December, 1958.

Key personnel were transferred from Derby to organise production at Shrewsbury, but most of the labour force of about 1,800 is local. Sentinel Works are now in full production as the headquarters of the oil engine division of Rolls-Royce Limited, which operates as a self-contained unit, with its own design, development and commercial organisations as well as the production shops and an apprentice school in which about 190 apprentices are instructed in accordance with the Rolls-Royce tradition. Contact is maintained with the aero engine development department at Derby, the facilities of which are available for use by the Shrewsbury development engineers.

COMPONENT PRODUCTION

Although the oil engine is fundamentally different from the aero engine, the same principles apply to the manufacture of both prime movers; everything must be of the highest possible quality.

The quantities of components required are insufficient to justify mass production methods, but advantage is taken wherever possible of line production. By such means and by the use of modern machine tools, coupled with efficient handling methods, production costs can be reduced. Jigs and fixtures are, of course, used as required.

Cylinder blocks are produced in a section of the machine shop which is the nearest approach at Shrewsbury to a mechanised transfer line. Four parallel lines of machine tools comprise the cylinder block machining section. A block enters the first line and is milled on the top and bottom faces on a duplex milling machine. It is then lifted off by a floor-controlled overhead power hoist and lowered to a roller conveyor, which takes it to the next machine, a radial drill. By movement to and from the machine tools and the conveyor, the block travels the length of the line and arrives at the end with numerous machining operations completed, including the rough machining of the half bearings for the crankshaft and rough boring of the liner bores.

In the second line, parallel with the first, the block travels in the reverse direction and is machined successively by machines linked directly by roller conveyor track in a straight run. Here the block passes through several drilling and tapping operations, multi-spindle machines being used. Next, it passes to the third line, which is similar to the first, the block undergoing further drilling operations and final machining of all bores. At the appropriate point in this line studs are driven and the bearing caps fitted so that the crankshaft bearings can be finish bored. Finally, the block passes to the fourth line, which is similar to the first and third, and a number of final machining operations takes place. At the end of the line the block receives a pressure test, and is sent to the stores.

A similar arrangement of machining lines is used to produce cylinder heads, and grouped machine tools are employed for crankshaft machining, movement between machines being entirely by power hoist in the latter case. An important feature of all the machining lines is their flexibility; an operation or group of operations can be omitted as circumstances demand, and adjustments to individual machine

loading can be made at any time without affecting the other machines in the line or group. Grouped machines in other parts of the machine shop deal with other types of machining, such as gear cutting and grinding, capstan and automatic lathe work and screwcutting.

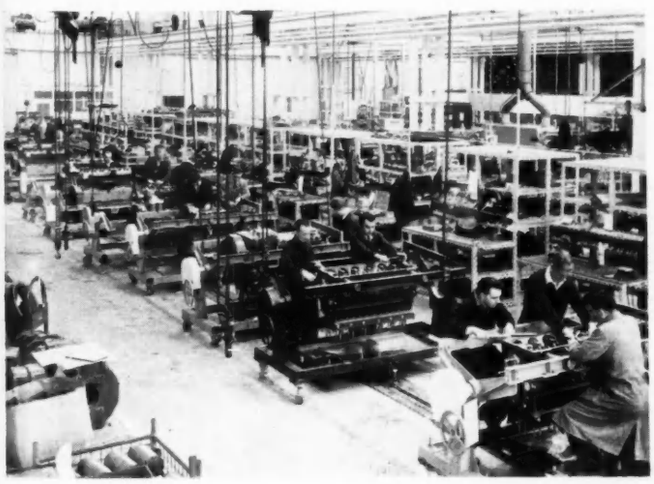
Inspection throughout the Rolls-Royce Shrewsbury works penetrates deeply into the production processes, and is carried out in close cooperation with other departments including, particularly, the design department, with which the quality standards originate.

OPERATOR CONTROL

Rolls-Royce have done much pioneer work in the field of operator control, that is, quality verification by the operator during or immediately after the production operation. Under such a system the old conception of an operator making the component while the inspector checks and accepts or rejects it becomes obsolete. Instead, the operator is provided with suitable inspection equipment and trained to use it on quality maintenance, and the inspector acts in an advisory capacity, assisting at the beginning of a production run (and during it, if asked to do so), and checking the operator's inspection equipment.

Operator control is an essential feature of the inspection system. Here an operator is checking crankshaft journals.

Engines are assembled on wheeled fixtures with provision for power movement to take the work to the operators.



Introducing operator control is a matter which takes time, but the principle has been in use at Rolls-Royce, Shrewsbury, long enough to have proved its value. It is already widely practiced in all production departments.

ENGINE ASSEMBLY

Components from the machine shop and from outside suppliers are held in a central stores ready for use in the engine building shop, which is organised on a batch assembly basis. For this purpose the engines are divided into a convenient number of sub-assemblies, the principal ones being: crankshaft with gears and sludge traps, cylinder heads, water pumps, lubricating oil pumps, connecting rods and pistons, camshafts, and backplates and gears. These sub-assemblies are produced on the basis of one man, one sub-assembly, but the operators change from one type of work to another to suit production arrangements. Fixtures are used wherever necessary, together with such tools as torque wrenches, to speed up the work and ensure that assembly is correct in all respects.

Sub-assemblies pass to the engine build line—all components and assemblies are correct to established limits when they are issued, and simple assembly is all that is necessary.

Assembly takes place on wheeled turn-over fixtures of special design, with provision for power movement down the line to take the work to the operators. The first stage is to wash the cylinder block in a machine of joint Curran Rolls-Royce design and then to pull in the camshaft bearings in a specially designed machine. In passing, it might be noted that the washing of components is practised extensively, and care is taken to see that all holes and apertures through which dirt could penetrate are sealed temporarily until assembly is complete. Partly assembled engines are covered completely when the workers leave for their meals or when work ceases for the day. This is done in addition to routine maintenance of a high standard of cleanliness in the shops generally.

As soon as a cylinder block has been fitted with its bearings it is bolted to the assembly fixture, studded and fitted with its cylinder liners, and building then proceeds in 12 major stages with two men at each stage. At the end of the line the engine, which is in basic form, without any special fittings which may have been ordered, is removed by mobile crane and taken to the test department.

Adjoining the building line is a pre-production engine assembly bay in which skilled fitters carry out the first test assemblies of new or modified engines, and so prove the building procedure. In this section also, special fittings such as torque converters, power take-offs, electric generators or gearboxes are added as required.

All Rolls-Royce oil engines are tested to a detailed schedule laid down by the design department and 14 test beds are provided for normal production testing. These beds, built by Heenan and Froude Limited in cooperation with Rolls-Royce, provide facilities for all normal production testing. Additional testing facilities, including a separate electronics laboratory dealing with vibration analysis are provided adjacent to the production test line for development purposes, and these special facilities can be used on production engines if necessary.

ROUTINE TESTING

Routine testing to schedule is very thorough. A C6NFL engine (a six cylinder unsupercharged engine giving 186 b.h.p. at 1,800 r.p.m.) may be taken as an example of the test procedure. It is rigged on the test bed, filled with the approved oil, and connected to the cooling water system. It is then run at 600 r.p.m. with a light load for 30 minutes. Next, the speeds and loads are increased in specified increments, each being held for a stated time. Brake loads, water and oil temperatures and pressures are recorded at the end of each period. Oil consumption is then checked over a run of two hours, and the engine is passed only if the consumption is less than 1 pint/hr. Governor tests follow, and the engine is then run to enable a power curve to be prepared at 2,000, 1,800, 1,600, 1,400, 1,200, 1,000 and 800 r.p.m. At each condition water and oil temperatures, fuel and oil pressures, power outputs and fuel consumption are recorded, and a smoke assessment is made.

Finally, if all the acceptance figures are achieved, the engine is drained of lubricating oil and filled with an inhibitor. All exposed pipes and outlets are blanked off and the engine is returned to the end of the assembly shop, to be prepared for despatch.

A similar procedure is adopted for all the engines in the range, testing being carried out complete with such fittings as gearboxes where appropriate, as, for example, with the C6SFLM supercharged engine which incorporates a marine reverse gear. For part of each test period an engine such as this is run with the gear in reverse. For all types of engine special performance or acceptance tests can be carried out, with the customer's representative in attendance.

PACKING AND DESPATCH

As soon as an engine has passed its test any special fittings which may have been ordered, such as torque converters, are fitted. It is then masked and spray painted in the standard Rolls-Royce grey, or in any other colour in accordance with the customer's order, and packed for despatch. Packing may range from simple crating for local delivery, to full tropicalisation. Facilities are available for all types of packing for both engines and spare parts.

Every engine is tested to a detailed schedule, and 14 test beds are installed for production testing.

Marketing

Salesmen on Course

A five-day residential course in sales management, organised by the British Institute of Management, will be held at St. Anne's College, Oxford, from Sunday, 28 June, to Friday, 3 July. The course is intended for men already in, or about to be promoted to, first level positions in sales management such as area sales managers and assistant sales managers. It will be primarily concerned with techniques of managing the sales force but will also deal with fundamental problems of marketing organisation and strategy. The selection, training, assessment and control of salesmen will be the principal items in a crowded timetable.

Another course, on " Modern Developments in Marketing and Distribution," has been organised by the Sundridge Park Management Centre, Bromley, Kent, over the weekend of 24 to 27 July. The emphasis will be on problems such as the choice of product mix, the routing of shipments and the location of warehouses for maximum profit or minimum cost. It will be given by Professor Marvin E. Mundel, the well-known American industrial engineer. The inclusive residential fee of £40 should be paid in advance to the Director of the Management Centre.

Films for Hire

The growth in the use of 16 mm films by firms has led Rank Precision Industries to publish a catalogue of over two hundred films " for free hire." The only costs incurred by the user are the small standardised postage and insurance charges. This catalogue (available free of charge on application) is issued by the GB Film Library, Perivale, Middlesex, which is one of the largest distributors of 16 mm films in Europe. The catalogue provides details of all sponsored films under 19 subject headings, ranging from accident prevention to manufacturing processes. In each case, there is a brief synopsis of the film, and its index number, the number of reels, and an indication of whether the film is in black-and-white or colour, is included

Latin American Music

An all-out drive for business has been undertaken in the hard-currency areas of Latin America by Aveling-Barford Limited of Grantham, who are one of Britain's most successful exporters of roadmaking and earthmoving machinery. They have behind them an outstandingly good performance in Canada and are now beginning to obtain orders from Latin American countries.

In Chile they have sold ten 13½ ton diesel " shuttle " dumpers, complete with spares, for use by Cia Minera Santa Fe in iron ore mines they operate on behalf of the Canadian Foreign Ore Development Limited. The order, which is worth £60,000, was obtained at the expense of established US exporters and is the company's first sale in Chile since the war. In Mexico, Aveling-Barford have sold fifteen 6 ton three-wheeled diesel road rollers valued at £30,000.

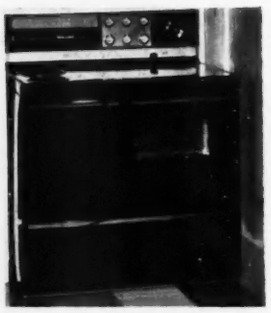
At Home

COMING SHORTLY

" Roast slowly for two and a half hours till tender right through, and baste all the time." That means that before you can have dinner you must plan ahead—and then wait. It means that there is an unbearable delay between coming home and having a meal, not surprising then that cooking is said to be a dying art and that the housewife—often at work herself these days —feels very disinclined to start on a hot job as soon as she comes in.

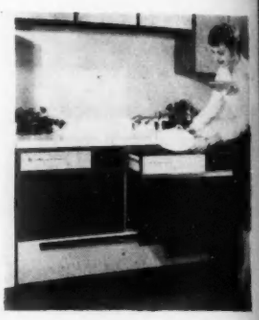
The trouble has not gone unnoticed. Cookers, both gas and electric, are now on the market with timing controls that allow all arrangements to be made before leaving in the morning: the oven will be switched on, held at the right heat and then switched off again after the set time, and the meal will be ready for the home coming.

As a possible alternative there are the infra-red cookers that take only a brief while to roast the largest chicken so that a meal can be prepared in a matter of minutes, not hours. Even quicker is the microwave technique that has become practicable during the last few years, reducing the time to seconds, but it is still not well known in this country.



A combined standard and microwave oven by Westinghouse.

Also by Westinghouse, an ultrasonic dish washer, built into sink or—



—as a self-contained table topped unit styled for the modern kitchen.

Living up to her reputation for labour saving gadgets in the home, America has developed the first combined standard and microwave cooker shown in the illustration. It is a modified version of a standard range having the larger of the two ovens equipped with a magnetron for microwave cooking as well as the standard bake and broil elements. It is claimed that " cookies " can be prepared in 190 seconds; cereals in 60 seconds and a complete breakfast in 60 seconds also. To heat baby's bottle takes a mere 25 seconds which should cut the noise level appreciably.

The heating effect of microwaves (those of less than about 10 cm wavelength) became very evident with work on radar when those who inadvertently stood in front of an open waveguide while the set was operating discovered the resulting burns. (Some experimental cooking was also carried out, usually on apples.) Medical science, too, has made use of them for diathermy work, owing to their deep penetration and the fact that no electrodes need be affixed to the patient. Their extended use in the kitchen will depend on price—and prejudice.

In these days of no help there is always one snag about meals at home—washing up afterwards. Dishwashing machines certainly are available which utilise jets of water to cleanse the pots, pans, and plates. As yet they are rather expensive and are regarded somewhat doubtfully. Not surprisingly they are found in comparatively few homes in this country. Again from America comes a dishwashing machine operating on a different principle—that of ultrasonics. Satisfactory prototypes have been made but as yet they are even more costly than existing types.

Ultrasonic cleaning has been known to industry for many years and it is therefore surprising that it has never made any real progress in the domestic field. Some work on applying it to laundries received a certain amount of publicity when it was started, but little has been heard for some time. For cleaning components the method has several big advantages. The action is thorough, for every part of the component is vibrated, and reaches all corners including those where ordinary scouring would be difficult. It is also said to be more effective than scouring in removing firmly adherent particles.

The dishwasher, two versions are illustrated, operates at 20 kc/s, stepped-up from the ordinary mains supply. A transducer imparts the vibrations to the water. As this frequency is above the range of the normal human ear the machine is silent in operation. All the pots and pans are stacked in the sink and the power switched on, the washing process taking only a few moments. As with industrial items the cleansing is very thorough and is said to be far superior in the matter of removing baked-on material. Moreover, there is no metal removal such as is inevitable when using a scouring cloth or powder. Nor are there any moving parts or water pumps.

One illustration shows the equipment applied to a steel sink unit, which can be used for all other normal purposes as well. This is a definite step towards removing the multiplicity of gadgets and machines required in the modern kitchen where space is always at a premium. Could it also replace the clothes washing machine? That would indeed show a saving which could easily offset the slightly higher cost of the ultrasonic washer as compared with its existing cousins.

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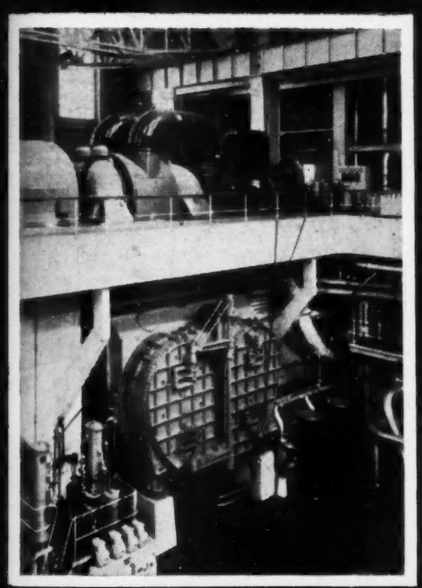

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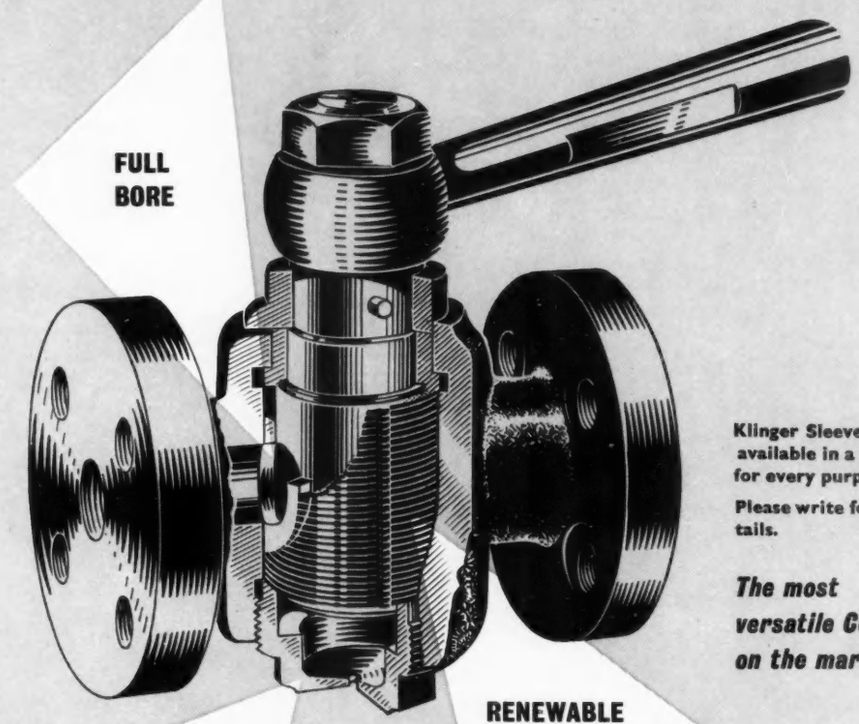

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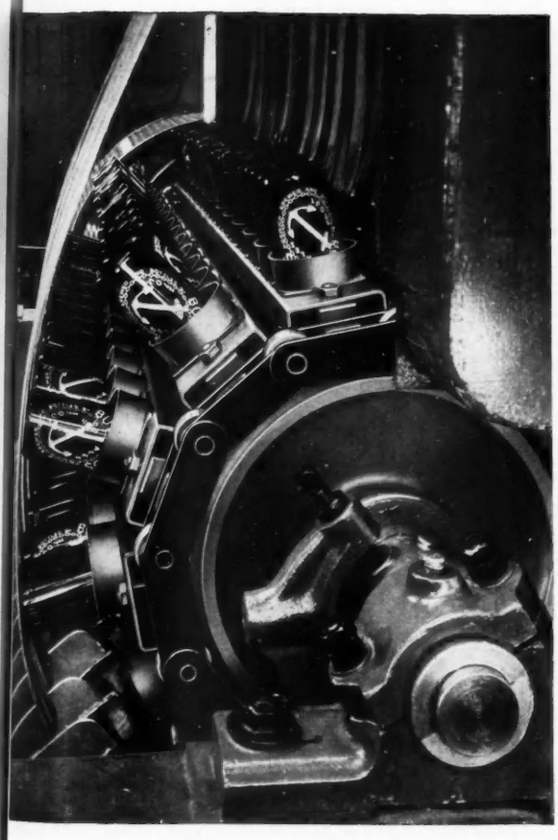

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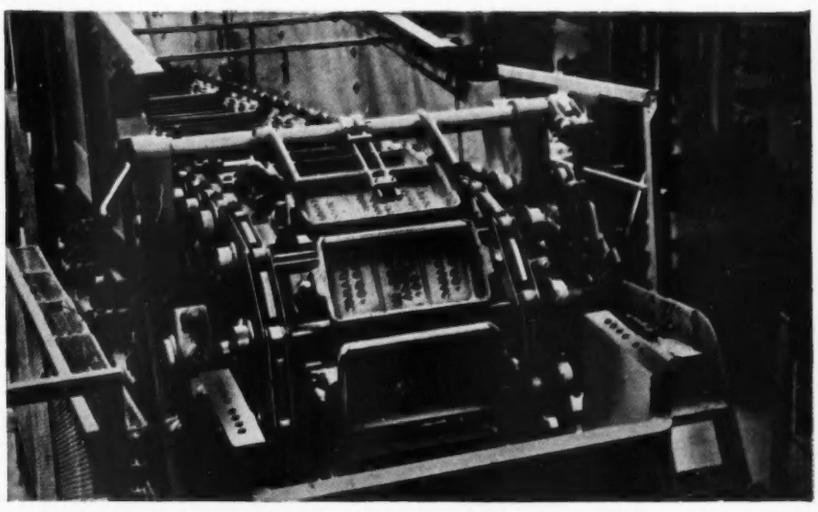

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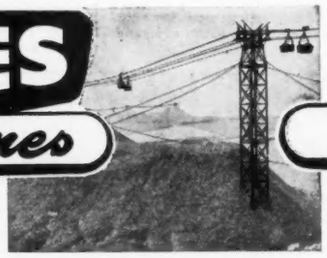

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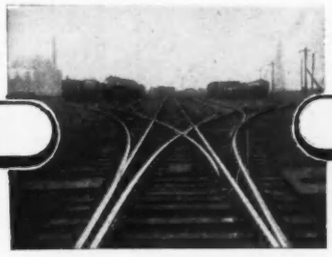

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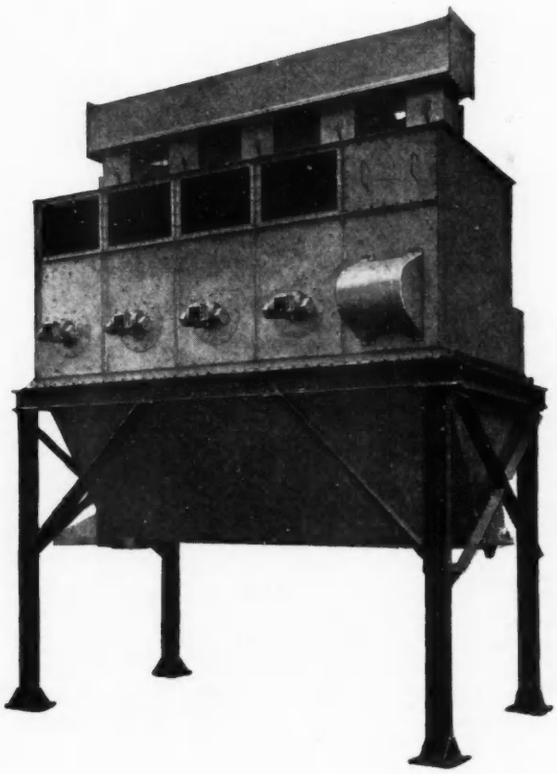

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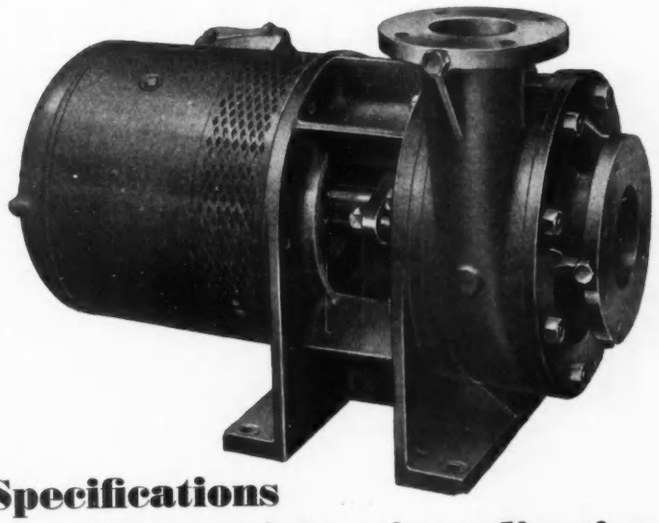

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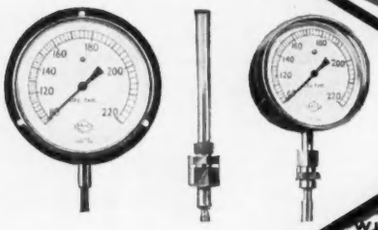

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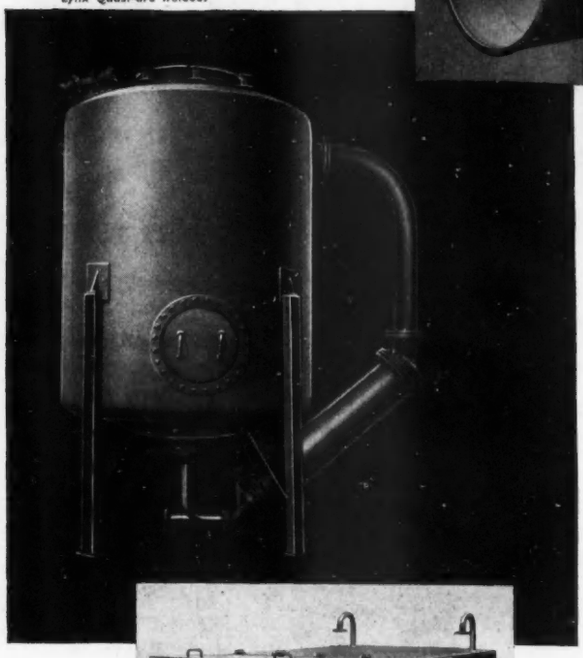

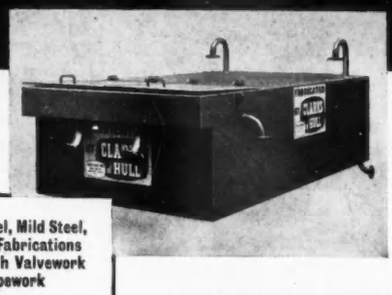

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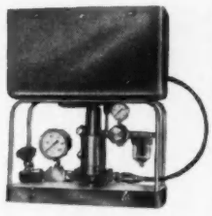

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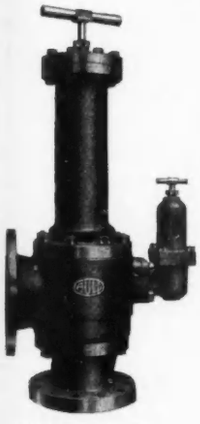

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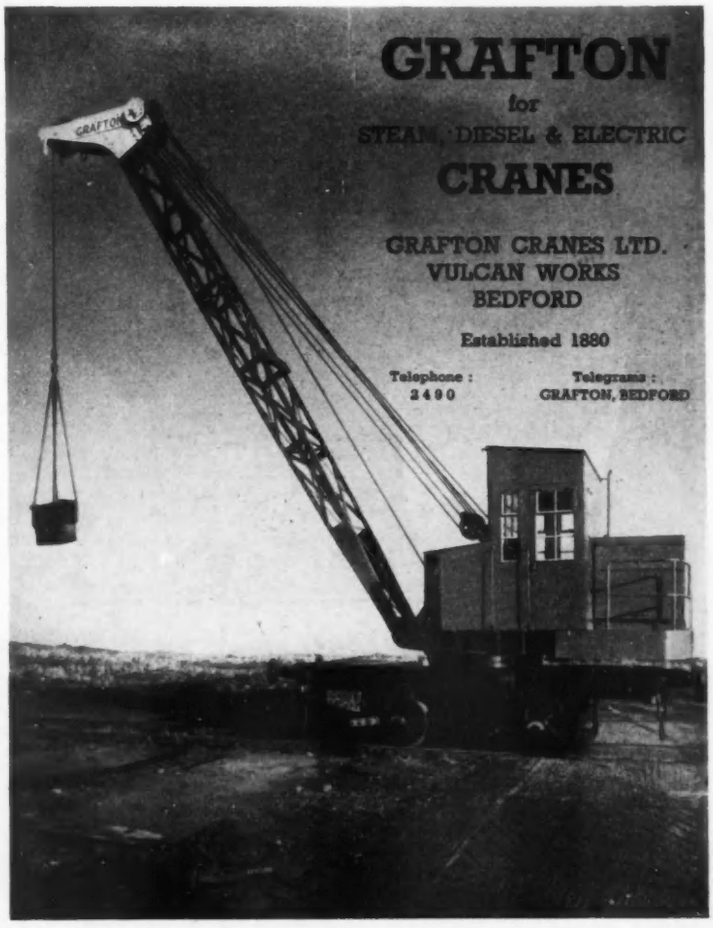

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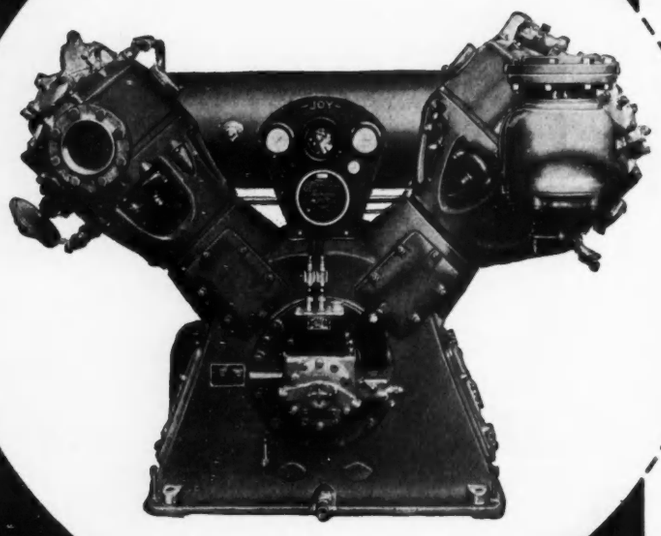

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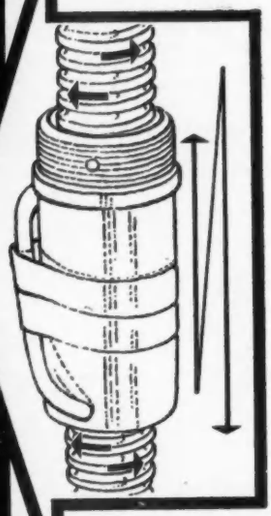

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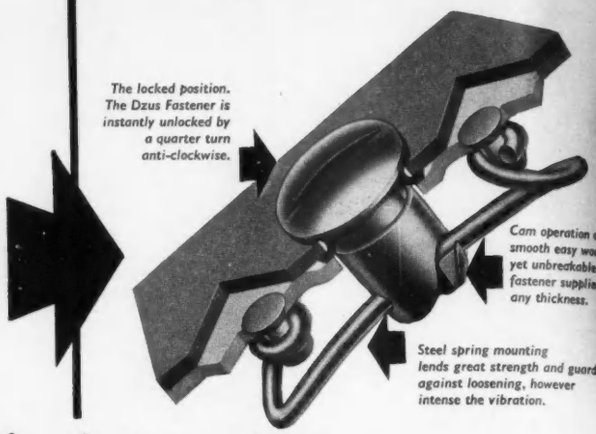
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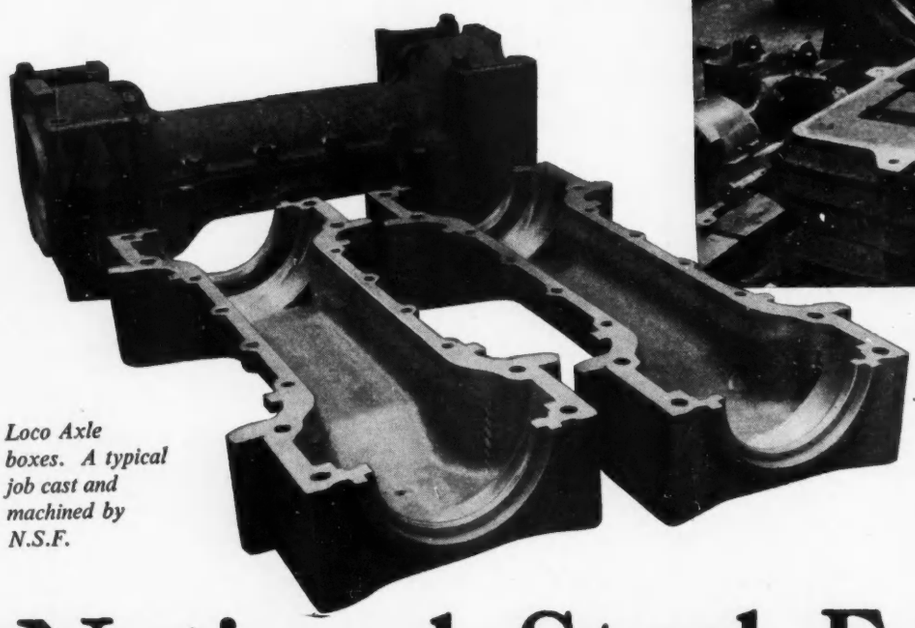

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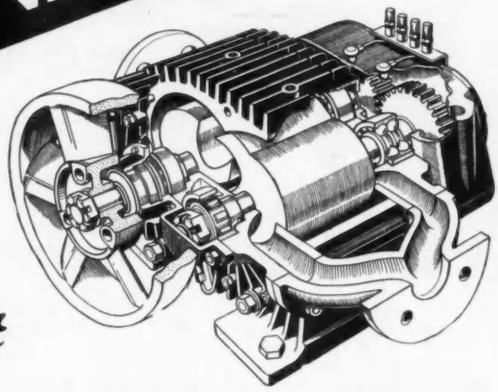

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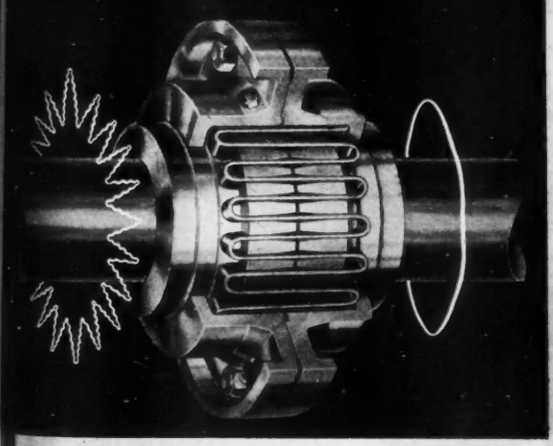

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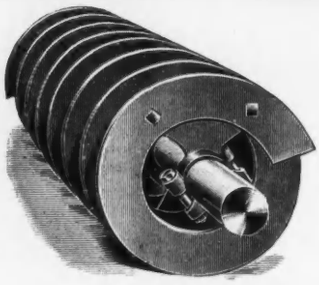

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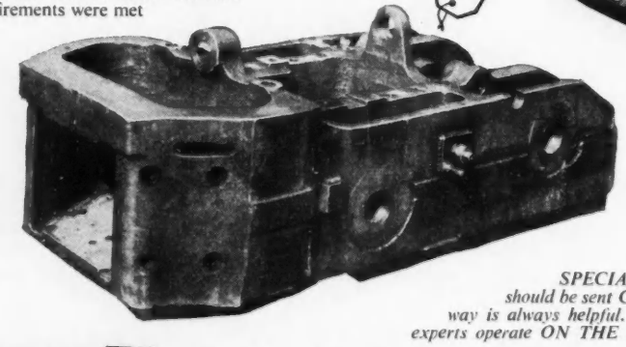

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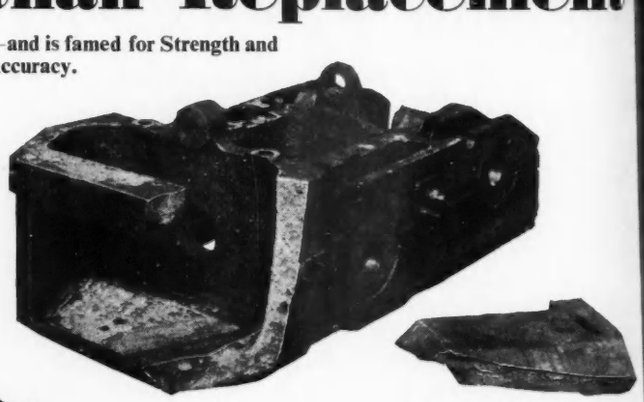

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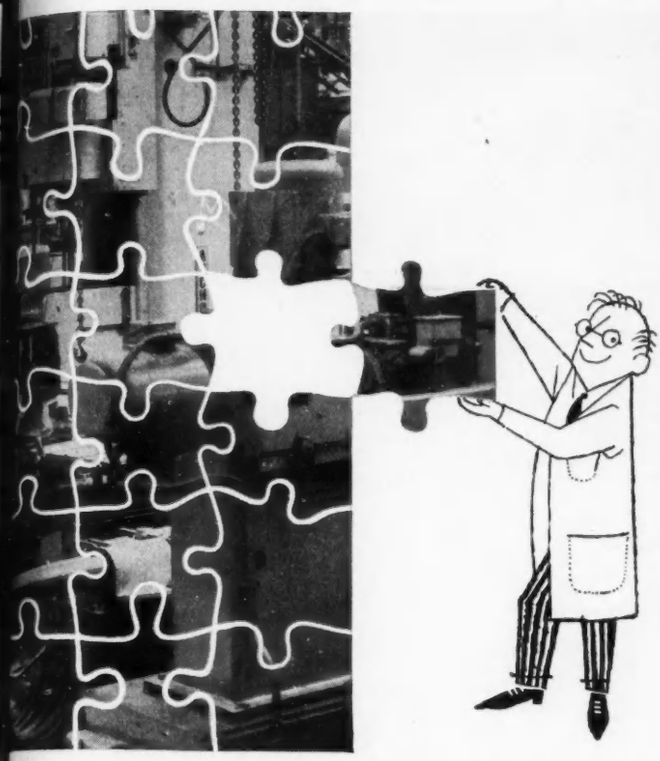

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his coupon is your opportunity to find out how Tecalemit Mechanical Lubrication can solve *your* ricatation problem. Fill it in and post it today. If you have a particular application or trouble-spot in mind, by all means enclose a note, a sketch or a drawing. You will be under no obligation whatsoever.

To TECALEMIT LTD (Sales E) PLYMOUTH, DEVON

Please send me full information on :—

NAME .....

COMPANY .....

ADDRESS .....

.....

- ☐ *Tecalemit BRENTFORD Mechanical Lubricators*
- ☐ *The TECALEMIT-BIJUR Single-line System*
- ☐ *All Tecalemit Mechanical Lubrication systems for oil and grease*
- ☐ *I enclose details of a particular lubrication problem*

TECALEMIT
The Authority on Lubrication

TECALEMIT LIMITED (SALES E)
PLYMOUTH · DEVON

T671

Flexello
CONSTANT QUALITY
CASTORS

Choose your castors from the largest range in Europe. Flexello will meet your special requirements individually, while our fabricating division designs and manufactures "special" castors for extra heavy and difficult applications.

illustrated are a small part of our vast range.

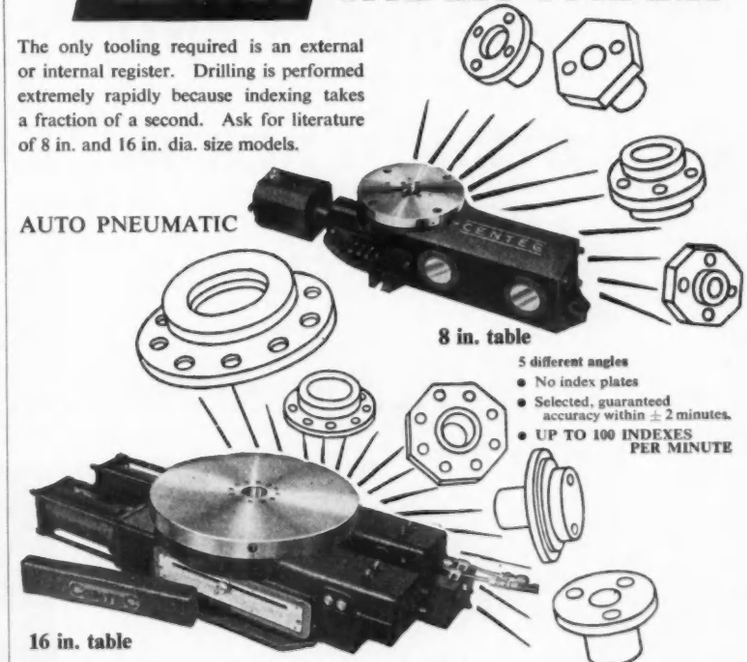
Write for illustrated leaflet to Dept. E.

FLEXELLO CASTORS & WHEELS LTD., SLOUGH, BUCKS. Tel: SLOUGH 24121

All Flanges can be drilled on the CENTEC INDEX TABLES

The only tooling required is an external or internal register. Drilling is performed extremely rapidly because indexing takes a fraction of a second. Ask for literature of 8 in. and 16 in. dia. size models.

AUTO PNEUMATIC

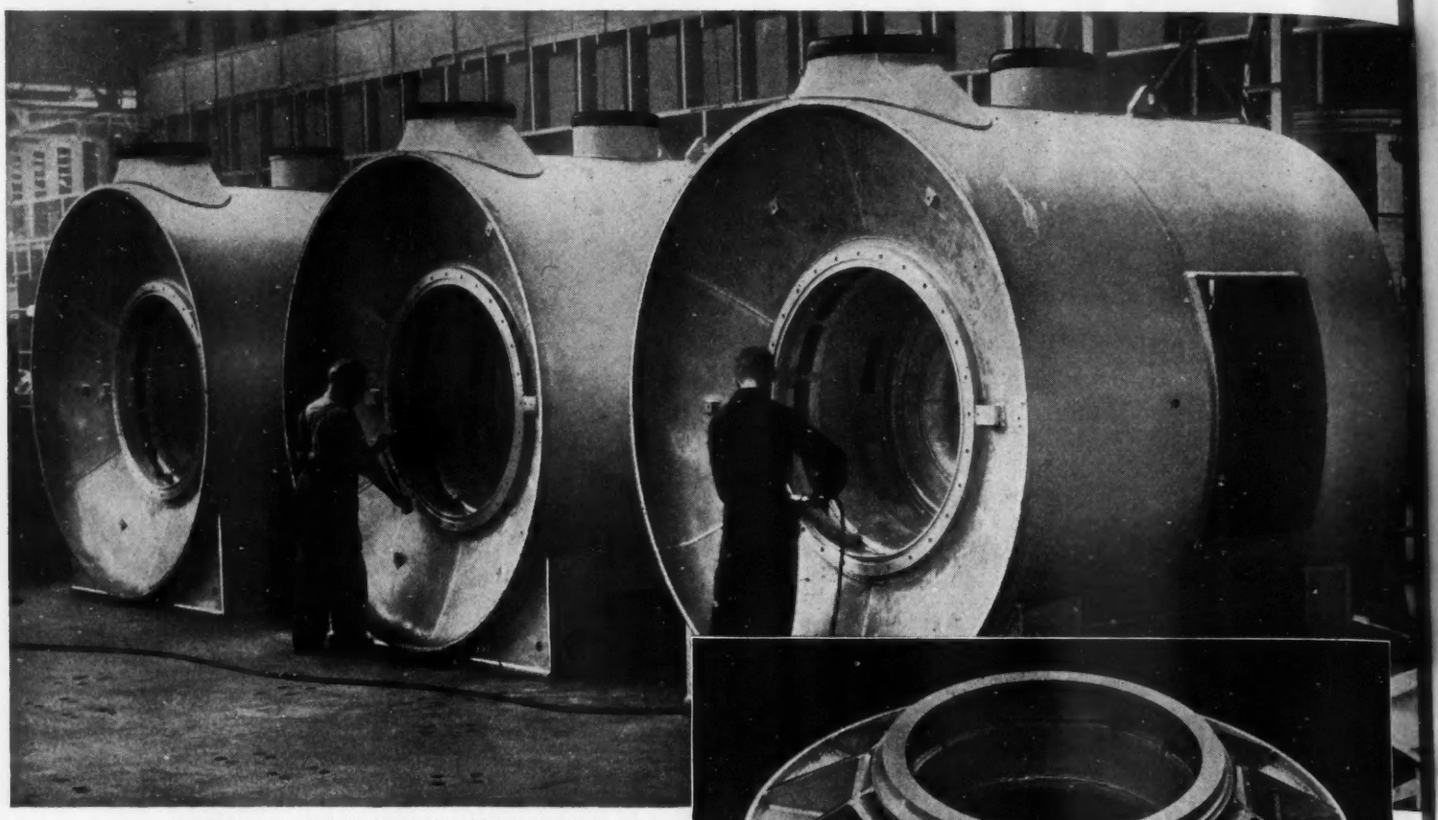


8 in. table

5 different angles
- No index plates
- Selected, guaranteed accuracy within ± 2 minutes.
- UP TO 100 INDEXES PER MINUTE

16 in. table
- 60 different angles
- No index plates
- Ordinary air pressure of 70/100 lbs.
- Accuracy of repetition 0·0005 in. at 20 in. pcd (NPL figs. available)

CENTEC MACHINE TOOLS LIMITED, CENTEC WORKS, HEMEL HEMPSTEAD, HERTS.
Telephone: BOXMOOR 584-5-6



Some of the many hundreds of welded aluminium fabrications built by Fairey for the United Kingdom Atomic Energy Authority. Each of the three examples at the top weighs 4½ tons ; the other weighs 18 cwt. and has a diameter of 8 ft. 5 in.

FAIREY PRESSURE VESSELS AND STRUCTURES IN STEEL AND ALUMINIUM

Fairey Engineering Ltd. offer a Fabrications facility equal to any in the world.

Pressure Vessels including refinery and chemical vessels, heat-exchangers, and large-diameter pipe, as well as many special types.

Structures such as bridge sections, roof trusses, crane jibs and oil derricks.

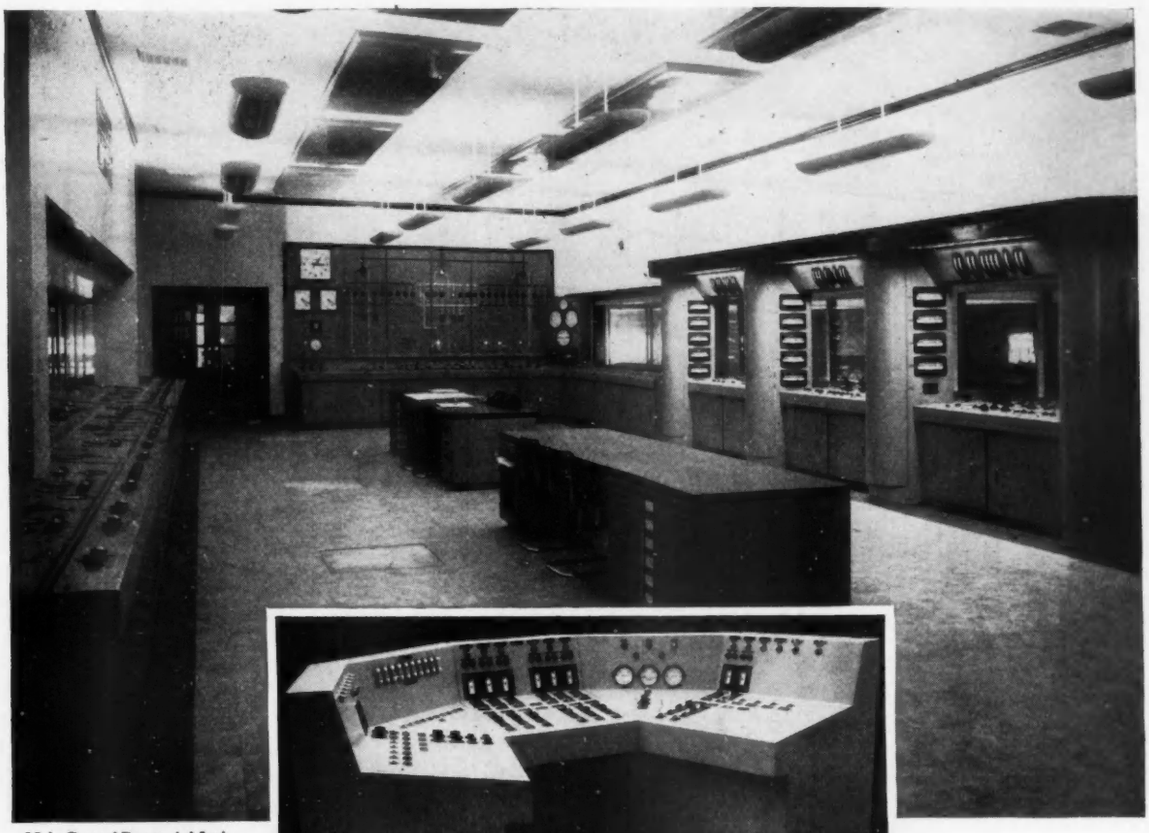
The Fairey Group of Companies provide a full Metallurgical Service, both in plant and at site, including X-Ray, vacuum and ultra-sonic testing; standards met include A.I.D., A.R.B. and U.K.A.E.A. and Lloyds Class 1.

For vessels or structures . . . in steel or aluminium . . . talk to Fairey first

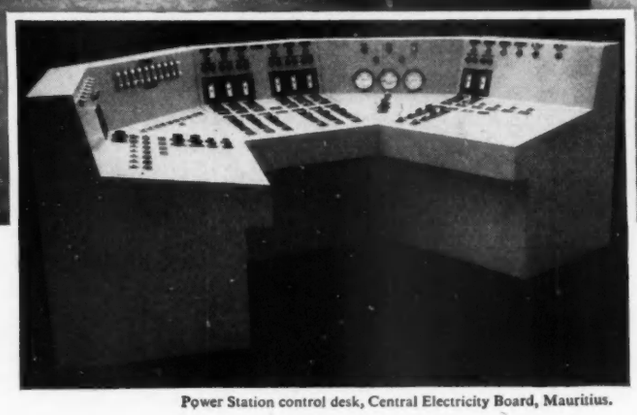
FAIREY ENGINEERING LIMITED

STOCKPORT · CHESHIRE

A Subsidiary of The Fairey Company Limited



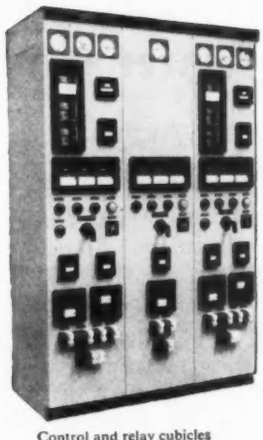
Main Control Room, Ashford Common Pumping Station of the Metropolitan Water Board.



Power Station control desk, Central Electricity Board, Mauritius.

Brush have considerable experience in the manufacture of Remote Control Boards for centralized operation and indication for power equipment.

Our Switchgear Division is always pleased to co-operate with project engineers and architects in the design of equipment for all applications.



Control and relay cubicles for industrial application.

BRUSH

REMOTE CONTROL BOARDS

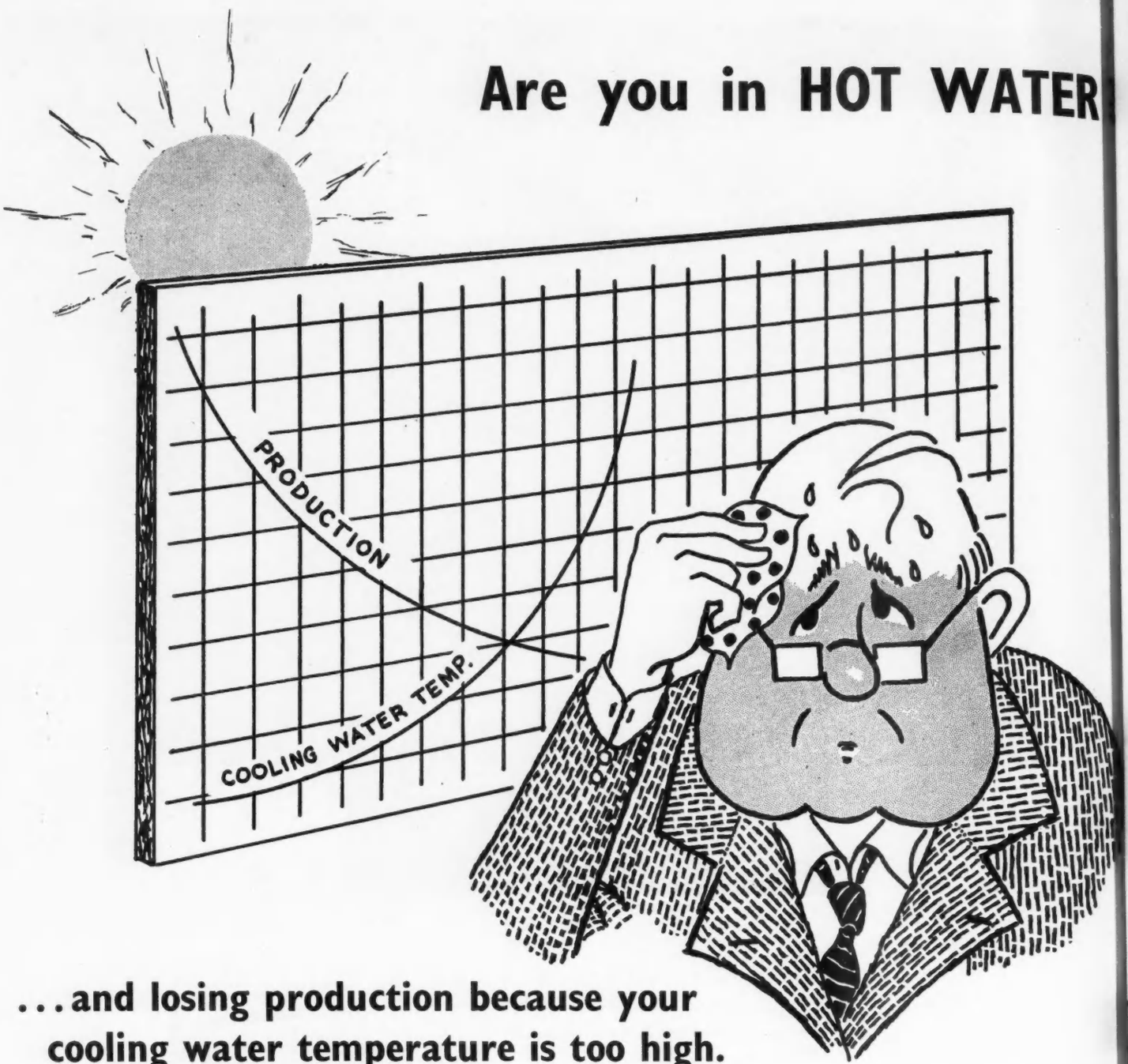
for power control of

SWITCHGEAR

BRUSH ELECTRICAL ENGINEERING CO. LTD. LOUGHBOROUGH, ENGLAND *(Member of the Hawker Siddeley Group)*

S6

Are you in HOT WATER



...and losing production because your cooling water temperature is too high.

Head Wrightson Processes offer the well-known high efficiency Fluor Cooling Tower with guaranteed cold water temperatures. We design, manufacture and erect pre-fabricated timber and precast concrete induced draught cooling towers for all purposes.

Consult us now and ensure that your production does not suffer in the future

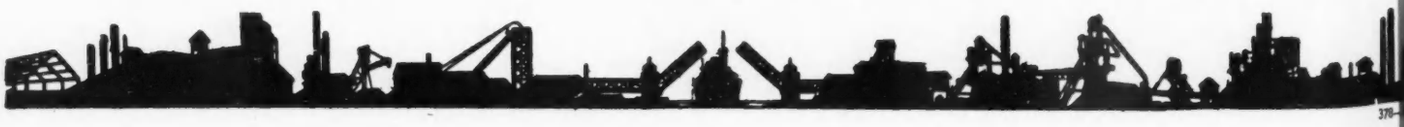
We invite you to write for details of this equipment

HEAD WRIGHTSON PROCESSES LTD

TEESDALE HOUSE, 16-26 BALTIC STREET, LONDON, E.C.1

Offices at: P.O. Box 1595 **SYDNEY** P.O. Box 1034 **JOHANNESBURG** P.O. Box 2608 **CALCUTTA** and P.O. Box 706 **HAMBU**

Associates in the U.S.A.: The Fluor Products Company, Los Angeles 22, New York, Chicago, Tulsa, etc.



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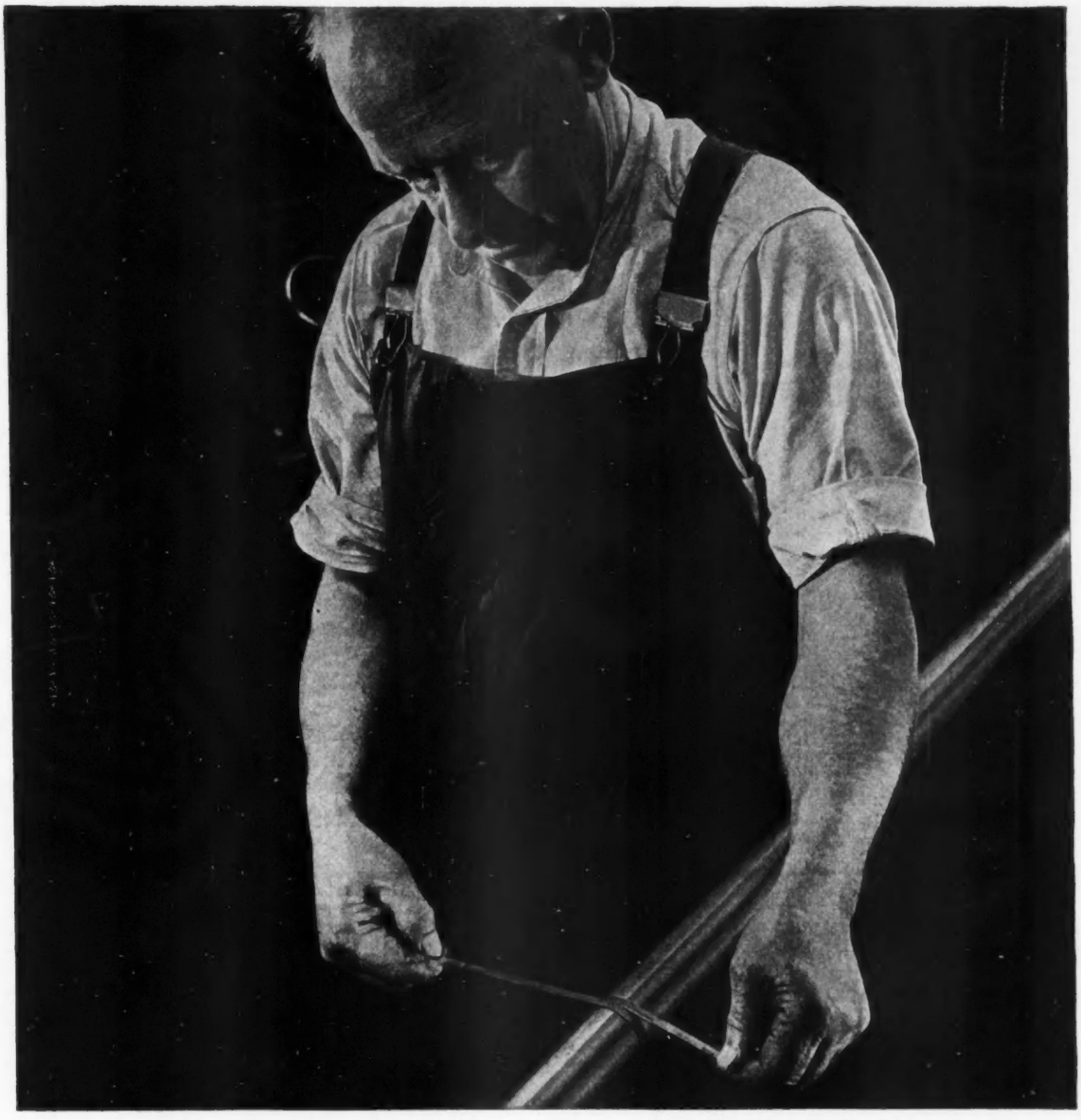


Diameter or Circumference?

It is probably true of most of us that we tend to forget that the simple tricks of our trade are not known to the layman.

We fell into this error in a recent advertisement which many of you will have seen—indeed quite a number of you have written to say you did!

In it we show the driver of a cable sheathing press checking the *diameter* of a cable by wrapping a steel tape around the *circumference!* You drew our attention to the "error"—but the driver *is*, in fact, reading the diameter on a specially calibrated tape on which the "inch" unit of measurement is π (3·14159265 to you!) times the true inch.

Even this simple assumption of knowledge shows once again that there is much more in the making of cable than is revealed in a specification.

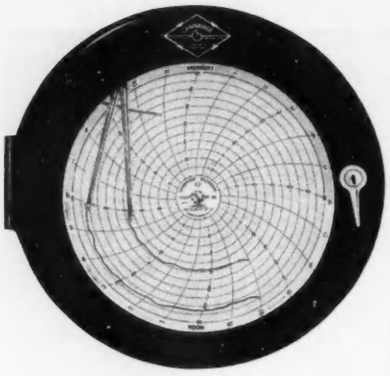
After more than 80 years at the game, there is much that we do almost subconsciously . . . *because we know it is right.* Call it experience, know-how, or what you will . . . by any name it means a better product.

A POWER IN THE ELECTRICAL WORLD

JOHNSON & PHILLIPS LTD.

CHARLTON LONDON SE7

FACTORIES IN GT. BRITAIN, AUSTRALIA, SOUTH AFRICA, INDIA AND PAKISTAN



(1) Double recorder for draught, pressure or temperature measurements.

(2) Draught or pressure gauge (or temperature indicator).

For ACCURACY ... RELIABILITY ... CLARITY

Choose

Cambridge

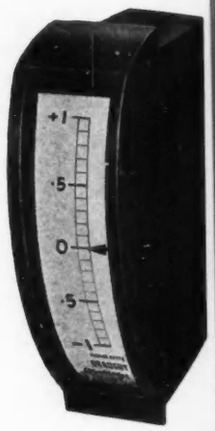
Draught and Pressure INDICATORS and RECORDERS

Over fifty years' specialised experience goes into the making of CAMBRIDGE Indicating and Recording Instruments. Here illustrated are just a few of the types available in the extensive CAMBRIDGE range designed to meet fully the requirements of Boiler Plants, Oil Refineries, Gas Works and other industrial undertakings.

The range includes: Draught and low pressure gauges and recorders (including portable instruments), and temperature indicators and recorders; Vertical scale indicators for draught, pressure and temperature; Controllers for pressure and temperature (indicating and/or recording).

Send for List G

For future publications, ask for Mailing Form G/4/59



(3) Unit-type vertical scale draught (or temperature) indicator.

CAMBRIDGE INSTRUMENT CO. LTD.

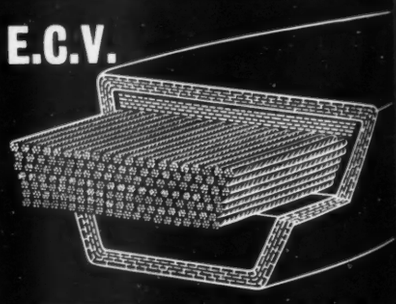
13 GROSVENOR PLACE, LONDON, S.W.1

Greater V-Belt reliability means more productivity

YOU CAN'T RISK costly shutdowns on full-scale production jobs – that's why Goodyear belts are the wisest choice for Multi-Vee drives. They can be fitted and forgotten – there's no better testimony to their trouble-free operation! There's a range of these 'job-designed' Goodyear V-Belts to give longer service and more efficient transmission on every type of drive.

The Goodyear Technical Man will gladly advise on the right belt for any job.

E.C.V.



BELTS FOR MULTI-VEE DRIVES

- Withstand high starting torques, sudden shocks and pulsating loads.
- Minimum stretch and creep.
- Tough rubber-impregnated fabric preserves the belt section, resists side-wear and gives positive grip.

GOODYEAR

INDUSTRIAL RUBBER PRODUCTS · CONVEYOR BELTING

V-BELTS · TRANSMISSION BELTING · HOSE

The New

'Engineering' Appointments

Section

All appointments advertisements in 'Engineering' will be in this position in future.

Atomic Energy Research Establishment

HARWELL

A PROFESSIONAL ENGINEER

is required to manage the engineering services of a large research laboratory used in chemical and metallurgical investigations of radioactive materials. Design and development work in liaison with scientists and project engineers is involved. Experience is needed in the control of technical supervisors and craftsmen and the manufacture, erection and commissioning of equipment.

Salary, £845-£1800, depending on age and experience.

Please send a POST CARD for details to **THE GROUP RECRUITMENT OFFICER (1411/26), U.K.A.E.A., A.E.R.E., HARWELL, BERKS.** Z 848

ENGLISH ELECTRIC

ATOMIC POWER DIVISION

Whetstone, Near Leicester

wish to appoint a

SENIOR RESEARCH ENGINEER

in the Mechanical Laboratories of the Research and Development Department.

The successful applicant will be required to lead a team investigating problems related to

FRICTION	**BEARINGS**
LUBRICATION	**SEALS**
WEAR	**SMALL PROTOTYPES**

Candidates should have some experience in these subjects and a particular interest in one or more of them would be a decided advantage.

Applications are invited from Graduate Mechanical Engineers with a number of years research experience, and whose background includes some chemistry and electrical engineering.

Please write giving details of education, qualifications and experience to **DEPT. C.P.S., MARCONI HOUSE, 336/7 STRAND, W.C.2,** quoting reference EG 1895E. Z 823

PUBLIC APPOINTMENTS

EAST MIDLANDS GAS BOARD
NOTTS AND DERBY DIVISION

DEPUTY DISTRIBUTION ENGINEER—DERBY DISTRICT

Applications are invited from suitably qualified persons for the above position at a salary within Grade A.P.T.9 (£827/927). There will be scope for promotion to A.P.T.10 (maximum £1002) for a man who proves his ability successfully to assume greater responsibilities.

Applicants should possess the Higher Grade Certificate (Supply) of the Institution of Gas Engineers or an equivalent qualification and should be experienced in all branches of gas distribution at both low and high pressures.

The position is pensionable and the successful applicant may be required to pass a medical examination.

Applications, stating age and experience, giving full particulars of training and qualifications, together with the names of two referees, should be submitted to the undersigned not later than 26th June, 1959.

K. L. PEARCE,
DIVISIONAL GENERAL MANAGER.
EAST MIDLANDS GAS BOARD,
NOTTS. and DERBY DIVISION,
P.O. BOX NO. 62,
FRIAR GATE,
DERBY. Z 830

CITY AND COUNTY OF BRISTOL
EDUCATION COMMITTEE
THE COLLEGE OF TECHNOLOGY, BRISTOL
(Selected for development as a College of Advanced Technology)

The Governors invite applications for **TWO POSTS** as **LECTURER** in Engineering Subjects to commence on, or as soon as possible after, 1st September, 1959. Posts additional to present establishment as result of continued expansion of work of College. Duties mainly with Sandwich Diploma Courses.

Candidates should be able to teach one or more of following subjects: Aerodynamics (Subsonic and Supersonic), Aircraft Structures, Mechanics of Fluids, Mechanics of Machines, Strength of Materials, Theory of Structures.

Candidates should hold a degree or equivalent, and have had teaching and/or industrial and/or research experience.

Salary: Burnham Scales: £1260 by £31 5s. 0d. to £1417 10s. 0d. Initial salary according to experience.

Application form, returnable within two weeks of appearance of this advertisement, and details, from REGISTRAR, COLLEGE OF TECHNOLOGY, ASHLEY DOWN, BRISTOL 7. Z 831

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY
(Faculty of Technology in the University of Manchester)

Appointment of

LECTURERS OR ASSISTANT LECTURERS IN MECHANICAL ENGINEERING

The Governing Body invites applications for Lectureships or Assistant Lectureships in Mechanical Engineering in The Manchester College of Science and Technology, with corresponding title and status in the University of Manchester.

The Department covers a very wide field in Mechanical Engineering, including Photoelasticity, Fatigue, Servo-mechanisms, Vibrations, Machine Tools and Production Processes and Heat Transfer. A special high level Diploma Course in Machine Tool Design lasting two years has just been inaugurated. All members of staff are expected to undertake, assist in or supervise research in their particular subject, for which facilities are excellent. The teaching is almost entirely confined to Graduate and Post Graduate Courses for Internal Degrees and Diplomas. Short courses for specialists in subjects of particular interest are offered each year.

Salary: Lecturer: £900 by £50 to £1350 by £75 to £1650. Assistant Lecturer: £700 by £50 to £850. Commencing salary according to qualifications and experience. F.S.S.U. and family allowances.

Conditions of appointment and form of application may be obtained from the REGISTRAR, THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY, MANCHESTER, 1. The last day for the receipt of applications is TUESDAY, 30th JUNE, 1959. Z 834

MINISTRY OF SUPPLY require **TECHNICIAN** at Blackburn, Lancs., to supervise skilled and semi-skilled staff engaged on inspection of components and assemblies for clockwork mechanisms. *Qualifications*: Recognised engineering apprenticeship. Experience of inspection of small precision components and sound knowledge of clockwork mechanisms. Possession of O.N.C. in Mechanical Engineering, appropriate C. & G. Final Certificates, or equivalent qualification desirable. *Salary*: £850 (age 30)-£1005 p.a. Application forms from MANAGER (P.E.1350), MINISTRY OF LABOUR AND NATIONAL SERVICE, PROFESSIONAL AND EXECUTIVE REGISTER, ATLANTIC HOUSE, FARRINGDON STREET, LONDON, E.C.4. Z 836

ENGINEERS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT
ALDERMASTON, BERKSHIRE

To assess the mechanical engineering requirements necessary to meet a tight production schedule; to integrate the production requirements of several divisions into a co-ordinated programme and to make a quick and reliable forecast of requirements from limited information.

A recognised engineering apprenticeship and a wide experience in all aspects of production required. Corporate membership of the Institution of Mechanical Engineers is essential.

SALARY :—£1345-£1800.

Contributory Superannuation Scheme. A house or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to the **SENIOR RECRUITMENT OFFICER** at above address. Please quote ref. 1939/26. Z 811

ENGLISH ELECTRIC

INDUSTRIAL GAS TURBINE DIVISION

Whetstone, Near Leicester

Two new appointments have arisen in this Division.

A DESIGN ENGINEER

is required to undertake work on both mechanical and aerodynamic problems related to Hydrogen Blowers for cooling large alternators and CO_2 circulators for Nuclear Power Stations.

Applicants should possess a degree in mechanical engineering and will have probably served a graduate apprenticeship. Experience in the design of axial flow compressors or related work would be a distinct advantage.

A DESIGN DRAUGHTSMAN

in the same department is required to work on the initial design, layout and complete schemes for gas circulators for Nuclear Power Stations.

Applicants who have served a recognised apprenticeship should be of about H.N.C. level and some experience in air, water or oil installations would be helpful.

Please write giving details of education, qualifications and experience to **DEPT. C.P.S., MARCONI HOUSE, 336/7 STRAND, W.C.2,** quoting reference EG 1896E. Z 824

BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION

A SENIOR INSTRUMENT DESIGNER

on the mechanical side is urgently required for interesting work associated with all kinds of instruments. Working conditions are admirable and a staff of draughtsmen are employed. Good dining facilities and a social club are among the amenities. The appointment is in the grade of Senior Technologist and the range of salary is from £1150 to £1500.

Anplication should be made as soon as possible to the

DIRECTOR, J. THOMSON, M.A., D.SC., M.I.E.E., "SIRA," SOUTH HILL, CHISLEHURST, KENT. Z 825

DRAUGHTSMEN

Experience in the

DESIGN OF COMPRESSORS OR PUMPS

required by well-established and progressive company situated in the Midlands. Good salary paid to suitable applicants. Apply Box Z828, offices of ENGINEERING.

FACTORY MANAGEMENT

A British company requires an ambitious **GRADUATE ENGINEER** of 30 to 35, experienced in production and shop-floor supervision. Starting salary up to £2000 p.a. The responsibilities are considerable and the £4000-£5000 bracket should be reached in a relatively few years. Please send age, education, industrial experience and salary to BOX Z 846, Offices of ENGINEERING.

ROYAL TECHNICAL COLLEGE, SALFORD

Applications are invited for the following posts in the DEPARTMENT OF ELECTRICAL ENGINEERING.

(a) **SENIOR LECTURER.** Salary £1417 10s. by £52 10s. to £1627 10s. (men).

(b) **LECTURER.** Salary £1260 by £31 10s. to £1417 10s. (men).

Successful applicants may be placed at intermediate points in these scales in accordance with previous experience in an equivalent capacity and/or industrial experience.

These vacancies offer an exceptional opportunity for those who wish to participate at the early stages in the current new developments in engineering education. Those appointed will be expected to lecture undergraduate courses, and post-graduate courses where appropriate. The greatest importance is attached to the undertaking of original research work of high quality, as an integral part of the work of the staff; time is allowed for this. In consequence, proven research ability is a strong recommendation for these appointments, and considerable weight will be placed upon this factor. For a candidate strongly qualified in this way, previous lecturing experience will be of secondary importance.

Further particulars and forms of application may be obtained from the REGISTRAR, ROYAL TECHNICAL COLLEGE, SALFORD 5, Lancs, to whom completed applications should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
CLERK TO THE GOVERNORS. Z 833

DERBY AND DISTRICT COLLEGE OF TECHNOLOGY

Principal: T. Heap, Ph.D., M.Sc., F.R.I.C., A.M.I.I.A.

Applications are invited for the following posts, duties to commence in September, 1959, or as soon as possible thereafter:—

LECTURER IN MECHANICAL ENGINEERING to teach subjects for O.N.C., H.N.C., Higher Diploma and London B.Sc. courses in Mechanical or Production Engineering. Applicants should have a degree or equivalent and good industrial and teaching experience.

ASSISTANT GRADE A OR GRADE B according to qualifications and experience to teach the subjects of science and technique to students in various trade courses including Machine Shop Engineering, Foundry, Steel Fabrication and Motor Vehicle Service. Applicants should have good industrial experience and appropriate academic qualifications.

Salaries in accordance with Burnham Further Education Scales as follows:—

Assistant Grade A—£489 15s. by £26 5s. to £945.

Assistant Grade B—£682 10s. by £26 5s. to £1076 5s.

Lecturer—£1260 by £31 10s. to £1417 10s.

In scales for Assistants Grade A and B allowances are payable for degree and training and up to 12 increments for approved industrial experience.

Application forms and further particulars can be obtained from the PRINCIPAL, DERBY AND DISTRICT COLLEGE OF TECHNOLOGY, NORMANTON ROAD, Derby, by whom completed applications should be received within two weeks of the appearance of this advertisement.

C. MIDDLETON,
SECRETARY TO THE JOINT COMMITTEE. Z 844

TRINITY HOUSE, LONDON

Applications are invited for the post of **ASSISTANT WORKSHOPS SUPERINTENDENT,** at the Workshops of the Corporation of Trinity House situated at Blackwall, E.14.

Candidates should be of British Nationality and between the ages of 32 and 42 years.

Applicants should have served a proper indentured apprenticeship and be either graduate or associate members of the Institution of Mechanical or Electrical Engineers. Practical experience in Workshop processes and management and the repair and maintenance of internal combustion engines, plant and equipment is essential. The possession of a 1st Class Engineers Ministry of Transport certificate would be an advantage.

The appointment is permanent and pensionable and subject to one year's probation. Salary £970 by various annual increments to £1,440 per annum maximum.

Applications in writing to the SECRETARY, TRINITY HOUSE, TOWER HILL, LONDON, E.C.3, by 30th June, 1959, stating age, qualifications, experience and enclosing copies of references. Z 853

GOVERNMENT OF QATAR—PERSIAN GULF

ASSISTANT DESIGN ENGINEER

THE GOVERNMENT OF QATARi n the Persian Gulf invites applications from graduate Civil Engineers seeking practical design experience, for the post of ASSISTANT DESIGN ENGINEER in the State Engineer's Office.

Applicants must have passed or be exempted from taking parts A and B of the Associate Membership Examination of the Institution of Civil Engineers.

Work includes the structural design of buildings and general civil engineering designs connected with a rapidly developing town of about 30,000 people.

Salary: Starting at Rupees 1775 per Arabic month (equivalent to £1598 per annum) with annual increments of Rs. 75/- a month to a maximum of Rs.1925 per Arabic month. A 3-year contract is offered subject to six months probationary period. Gratuity payable on completion of contract. Leave six days for each month of duty. Free passages, accommodation, fuel, light and water. No income tax.

Applications endorsed "Assistant Design Engineer" should be sent in duplicate to: C. TENNANT SONS & CO. LTD., 4, COPTHALL AVENUE, LONDON, E.C.2, giving full details of training, etc., age, nationality, religion, marital status, the names of three referees and a recent dated photograph. Z 842

CITY OF LEICESTER
EDUCATION COMMITTEE
LEICESTER COLLEGE OF TECHNOLOGY AND COMMERCE

Principal: R. E. Wood, M.Sc., F.Inst.P.

Applications are invited for the post of **LECTURER** in the Department of Electrical Engineering. Applicants should have an Engineering Degree, or equivalent qualification, together with industrial and teaching experience. The post is mainly concerned with National Certificate and Diploma courses, but applicants should be capable of teaching some subjects of Part III of the I.E.E. examinations.

Salary, Burnham Technical Scale, £1260 by £31 10s. to £1417 10s. per annum.

Forms of application (to be returned as soon as possible) and further particulars can be obtained from the REGISTRAR, COLLEGE OF TECHNOLOGY AND COMMERCE, LEICESTER. Z 8

THURROCK TECHNICAL COLLEGE
WOODVIEW, GRAYS, ESSEX

Required for 1st September, 1959:

ASSISTANT TEACHER GRADE "B" Mechanical Engineering required to teach Thermodynamics to Higher National Certificate standard. Applicants should have graduate qualification or equivalent, industrial experience, and some teaching experience. Post includes responsibility for the Thermodynamics and Heat Engines Laboratory and the teaching of allied subjects at a lower level.

Salary in accordance with Burnham Scale, 1956 plus 5 per cent addition.

£682 10s. by £26 5s. to £1076 5s.

plus additions for approved qualifications and training.

Application forms from the PRINCIPAL. Closing date, 30th June. Z 81

MIDDLESEX COUNTY COUNCIL
EDUCATION COMMITTEE
HARROW TECHNICAL COLLEGE
Station Road, Harrow, Middlesex

Required for 1st September, 1959:—

ASSISTANT GRADE A FOR MATHEMATICS. Duties will be mainly with G.E.C. courses and National Certificate courses in Chemistry and Physics.

Salary in accordance with the Burnham (Technical) Report, *i.e.*, (for men), £498 15s. by £26 5s. to £945 per annum plus London allowance and other additions for qualifications and previous experience as appropriate.

Application forms (foolscap s.a.e.) from the PRINCIPAL. Closing date 1st July.

C. E. GURR, M.Sc., Ph.D.,
SECRETARY TO THE
EDUCATION COMMITTEE. Z 815

SOUTHERN RHODESIA GOVERNMENT

VACANCY: MECHANICAL ENGINEER

CENTRAL MECHANICAL EQUIPMENT DEPARTMENT

Applications are invited for the post of **MECHANICAL ENGINEER** in the Central Mechanical Equipment Department.

Applicants must be Associate Members of the Institute of Mechanical Engineers, have had sound mechanical engineering experience connected with the repair of vehicles and construction equipment. In addition applicants should have had experience of:—

(*a*) Man management and management control.
(*b*) Labour control systems.
(*c*) Methods engineering, time and motion study and job analysis.

Salary Scale: £1925 by £75 to £2000 by £50 to £2050.

Application forms and further details from the SECRETARY (R), RHODESIA HOUSE, 429 STRAND, LONDON, W.C.2. Z 839

BUCKINGHAMSHIRE EDUCATION COMMITTEE
CHESHAM TECHNICAL INSTITUTE
(Organising Master: S. E. Chapman, B.Sc.)

Required for September, 1959

GRADE A ASSISTANT to teach Workshop Engineering subjects and/or Motor Vehicle Work with day release and evening class students. The candidate appointed would also be required to undertake some work with a new Pre-Technical course at the Institute and one with ability to teach ancillary subjects or English would be preferred.

Forms of application may be obtained by forwarding a stamped addressed envelope to the ORGANISING MASTER AT WHITEHILL, CHESHAM, to whom completed forms should be returned as soon as possible. Z 835

(*a*) **EXPERIMENTAL OFFICERS,**
(*b*) **ASSISTANT EXPERIMENTAL OFFICERS.** Pensionable posts for men and women in Mathematics, Physics, Meteorology, Chemistry Metallurgy, Biological Sciences, Engineering, Miscellaneous (Geology, Library and Technical Information Services). Candidates must, on 31.12.59, be at least 26 and normally under 31 for (*a*), and at least 18 and normally under 28 for (*b*). Qualifications should normally include H.S.C., or G.C.E., or equivalent, or H.N.C. or University degree. Provisional admission if taking examinations in 1959. Men's salary scale (London): (*a*) £1005-£1233; (*b*) £405 (at 18) to £710 (26 or over) rising to £880. Promotion prospects. Further education facilities.—Write CIVIL SERVICE COMMISSION, 17 NORTH AUDLEY STREET, LONDON, W.1, for application form, quoting 894-95/59. Z 855

THE UNIVERSITY OF LIVERPOOL
Applications are invited for the post of
STANT LECTURER OR LECTURER
Department of Fluid Mechanics. The initial
will be within the range £700-£1250 per
, according to age, qualifications and experi-
Candidates should have an Honours degree
perience in Hydraulics would be an advantage.
plications, stating age, academic qualifications
perience, together with the names of three
, should be received not later than 6th July,
by the REGISTRAR, from whom further
ulars of the conditions of appointment may be
ined. Z 820

ROYAL MINT has a vacancy for a
CHANICAL ENGINEER. Pensionable post.
alification preferably Honours Degree in Mech-
l Engineering with metallurgical knowledge
two years' practical experience.
ply in writing for particulars to ESTABLISH-
NT OFFICER, ROYAL MINT, LONDON,
Z 832

LLEGE OF TECHNOLOGY, PORTSMOUTH
RESEARCH SCHOLARSHIP
plications are invited for a full-time Research
olarship in Pure or Applied Science for a period
two years. The successful candidate will be
uired to undertake teaching work not exceeding
hours per week for which the Scholar will be paid.
approximate annual value of the Scholarship
£500.
plications, with all relevant information
uld be made forthwith to the REGISTRAR
THE COLLEGE. Z 856

CITY OF CARLISLE
TECHNICAL COLLEGE
Applications are invited for an
ISTANT GRADE A IN WORKSHOP
GINEERING, duties to commence 1st Septem-
.
ndidates should be prepared to teach some of the
owing:—Workshop Engineering, Mechanical Engi-
ring Craft Practice, Sheet Metal Work, Welding
ity and Guilds Courses.
plication form and further particulars from the
RECTOR OF EDUCATION, 19 FISHER
REET, CARLISLE. Closing date by 29th June,
. Z 814

APPOINTMENTS OPEN

CHIEF PLANNING ENGINEER required by
ct engineering company in Middlesex to supervise
lanning, J & T Design and Estimating work.
e position offers unlimited scope to an enthusiastic
rson, and carries with it an excellent salary.—
tails and experience in first instance to BOX
50, Offices of ENGINEERING.

ASSISTANT TO CHIEF ENGINEER required
r Medium/Large Food Factory in Hull. Age
-40 years. Sound theoretical knowledge of Steam
ooling, Refrigeration and Electrical Engineering
ssential, together with practical experience in at
ast two of these branches and Drawing Office is
quired. Previous experience in the successful
ontrol of Staff is absolutely essential. All applicants
ust state age, experience and salary required.—
rite in confidence to BOX Z847, Offices of
NGINEERING.

SENIOR METHODS ENGINEER required to
ake charge of small section responsible for planning
ll operations ancillary to machining and assembly
f high speed diesel engines. Experience of modern
oundry techniques essential. Preference will be
iven to applicants who have H.N.C. or equivalent,
ogether with an apprenticeship and subsequent
achine shop experience.—Write, giving full parti-
ulars and stating salaries earned, to DEPUTY
ANAGER, PERSONNEL DEPARTMENT, F.
ERKINS LIMITED, PETERBOROUGH. Z 841

ASSISTANT ENGINEER for site of new power
tation Richborough, Kent. Qualifications: Cor-
orate Member Institution of Civil Engineers, and
xperienced in reinforced concrete construction.
alary according to qualifications and experience.—
OTT, HAY & ANDERSON, 9, IDDESLEIGH
OUSE, CAXTON STREET, WESTMINSTER,
W.1. Z 837

DRAUGHTSMAN, with general engineering
xperience, for work on Compressors and Blowers.
tate age, experience, and salary required. Canteen
acilities and bonus scheme.—GEORGE WALLER
& SON LTD., STROUD. 'Phone: BRIMSCOMBE
201. Z 817

Applications are invited from the following Technicians for the Engineering Department at Ferodo Limited, Chapel-en-le-Frith:

DESIGN DRAUGHTSMEN having experience in machine design, works layouts, heating and ventilating, and mechanical services; also civil engineering design. Ref. E.1.

TOOL DESIGN DRAUGHTSMEN having experience in Jigs, moulding die and press tool design. Ref. E.2.

PROJECT ENGINEERS trained in Production Engineering and capable of dealing with factory layouts, services and special plant design from initial investigation through preparation of estimates and reports to installation and final hand over of plant to the works. Ref. E.3.

CHEMICAL ENGINEERS capable of designing and commissioning chemical plants including storage, handling, mixing machines and synthetic resin plants. Ref. E.4.

TRAINED METHODS STUDY ENGINEERS having experience in Methods Study practice with an engineering background and familiar with batch production requirements. Ref. E.5.

ELECTRICAL DESIGN ENGINEERS able to deal with works electrical requirements (A.C. and D.C.) for machine drives, H.V. and L.V. distribution, lighting, electronic controls and instrumentation, etc. Ref. E.6.

In all cases the status will be technical Officer and there is a contributory Pension Scheme.

The minimum qualification required is H.N.C. or equivalent, and applicants should reply quoting ref. No. and giving age, salary required and details of previous experience, to the PERSONNEL MANAGER, FERODO LIMITED, CHAPEL-EN-LE-FRITH, VIA STOCKPORT. Z822

WANTED. REPRESENTATIVES for correspondence abroad, high earnings, written instructions. Write: FORTUNA PUBLISHING CO., VIENNA 1/8, POSTFACH 49, AUSTRIA: G 824

COMPETENT PRACTICAL ENGINEER required for PLYWOOD FACTORY in West Africa. To be responsible for maintenance also to draw plans for expansion scheme, supervise extensions, erect machinery, etc.; some knowledge of Steam Boilers and Electronics necessary. Tours of 15 months thereafter three months home leave and passages and living accommodation provided.—Write giving full particulars of experience, salary, etc., to BOX Z 774, Offices of ENGINEERING.

TEST HOUSE ENGINEER required for organising and running of test house in established diesel manufacturing Company in East Anglia. Applicant should have first-class knowledge of test bed procedure, and should also be a fully experienced electrical engineer.

Ability and personality to organise and take full responsibility for testing programmes.

University or H.N.C. qualifications an advantage. Good salary will be paid to the right man.

Applications in writing, stating age, qualifications and experience, to LABOUR OFFICER, BOX TH.733, A.K. ADVTG., 212a SHAFTESBURY AVENUE, LONDON, W.C.2. Z 794

PIPEWORK DRAUGHTSMAN (30-40), H.N.C. or equivalent is required by a well-known Group of Companies in the London area. The successful applicant will have considerable experience in the layout of Chemical process plant and services. Appropriate salary will be paid. Pension and Profit Participation Schemes in operation.—Write giving full details of age, experience and qualifications and quoting Reference PWD30 to BOX Z 787, Offices of ENGINEERING.

EDITORIAL ASSISTANT required for monthly journal specialising in world hydro-electric development. Should be young engineer, preferably civil and with some practical experience, with an aptitude for technical writing. Some knowledge of languages an advantage.—Apply: THE EDITOR, "WATER POWER," 33 TOTHILL STREET, S.W.1. Z 796

THE BEECHAM GROUP have vacancies in the London area for
TWO SENIOR DRAUGHTSMEN, H.N.C. or equivalent with experience in plant layout and general engineering. Appropriate salary will be paid. Profit Participation and non-contributory Pension Schemes are in operation.—Applications, in writing only, giving full details of age, qualifications and experience and quoting reference SD/31, to be forwarded to the PERSONNEL CONTROLLER, BEECHAM GROUP LIMITED, BEECHAM HOUSE, GREAT WEST ROAD, BRENTFORD, MIDDLESEX. Z 804

DEVELOPMENT ENGINEER

An Engineer for the design and development of carbide tipped tools is required by MUREX LIMITED, RAINHAM, ESSEX. Candidates, preferably 32-40 years of age and holding Higher National Certificate or equivalent qualifications, must have first-class experience in the application of carbide to modern production processes, including milling, turning and drilling. Drawing office experience in tool and cutter design is desirable.

The appointment will require residence within reach of Rainham but will involve periods of travel within the British Isles. Salary according to qualifications. Contributory Staff Pension Fund in operation.—Write, giving full particulars to Staff Department. Z 851

THE METAL BOX COMPANY LIMITED
TECHNICAL ENGINEERING DIVISION

are expanding their **ENGINEERING RESEARCH AND DEVELOPMENT** activities on Plastics Technology in the packaging field and have a

SENIOR VACANCY

at their laboratories at Borehamwood.

This is concerned with theoretical and experimental aspects of the technology and may appeal to engineers with a Ph.D. or to a physicist or mathematician with an interest in applied work.

SALARY WILL BE ASSESSED, ACCORDING TO ACHIEVEMENT AND EXPERIENCE, WITHIN THE £2,000 PER ANNUM BRACKET.

Applications to :—
Staff Division,
The Metal Box Company Limited
37, Baker Street, London, W.1
quoting reference TED/7. Z 827

UNILEVER LIMITED
PATENTS DEPARTMENT

A vacancy exists in the Company's Patents Department in London for an **ENGINEER OR PHYSICIST** of degree standard. Previous patent experience is desirable, but not essential.

The work will cover the very wide range of interests of the Unilever organisation and will provide extensive experience in all aspects of British and foreign practice and the opportunity to qualify as a Patent Agent.

An attractive salary will be offered commensurate with qualifications and experience.

Write to the **HEAD OF PATENTS DEPARTMENT, UNILEVER LIMITED, BLACKFRIARS, LONDON, E.C.4.** Z 826

DRAUGHTSMEN
SENIOR AND JUNIOR DRAUGHTSMEN

are required for original and interesting work on marine nuclear propulsion machinery installation.

Applications are invited from suitably qualified Engineering Draughtsmen having held responsible posts in Drawing Office procedure and Contracts work. Marine experience is essential. There are also a few vacancies for Juniors interested in this particular field.

A modern Drawing Office, pleasantly situated on the South Coast forms a further inducement to enter a new field presenting a constant challenge to ingenuity and design.

Salary will be in accordance with age, experience and qualifications.

Please write with full particulars to:

THE MANAGER,
VICKERS-ARMSTRONGS (ENGINEERS) LTD.,
OAK YARD, HAZEL ROAD, ITCHEN, SOUTHAMPTON.

Z 852

DRAUGHTSMAN

Preferably experienced in machine and detailed design work and plant layout. Must have O.N.C. at least, and at least 3 years' shop floor experience plus at least 2 years in drawing office. This is an excellent opportunity in the small drawing office of an internationally known manufacturing company in the Outer London area (West) which is engaged in a large modernization programme. Good conditions of employment. Send full details of age, education, experience and present salary to BOX Z 849, Offices of ENGINEERING.

DESIGNER/DRAUGHTSMAN required for Engineering firm in London area. Must have expert knowledge of contractors plant in general and pumps in particular. First class opportunity for hard working enthusiastic and capable man with ideas to join a progressive organisation. Only applicants with experience of this type of engineering will be considered. A permanent position with good prospects and salary is offered to successful applicant. —Please write, in confidence, stating age, qualifications, past and present positions and any other worthwhile particulars to BOX Z 821, Offices of ENGINEERING.

ASSISTANT ENGINEER required for tube manufacturing concern near Leicester. Age range 23/24. Candidates should preferably have an electrical background, although this is not absolutely essential, and minimum qualifications required are Higher National Certificate or University Degree. The successful applicant will be responsible for new installations and the development of existing plant. This is an interesting opportunity for a young man who wishes to widen his experience in a progressive and stable industry.—Applications, giving full details of experience, qualifications and salary required, should be addressed to the CHIEF ENGINEER, TUBES LTD., DESFORD LANE, KIRBY MUXLOE, Nr. LEICESTER. Z 812

LEADING LOADING SHOVEL MANUFACTURER

has a vacancy for a

DESIGN DRAUGHTSMAN

for the design and progressing of new developments in hydraulic loading shovels.

Applicants should have experience in medium general engineering fabrication and transmission design and should be able to work with a minimum of supervision. H.N.C. minimum qualification.

Apply in writing to

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F. E. WEATHERILL LTD.
TEWIN ROAD,
WELWYN GARDEN CITY
HERTS. Z751

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Wide knowledge and experience of the machine tools and tooling used in the medium/heavy engineering industry essential.

Applicants should have a knowledge of British, Continental and American machine tools, and be able to inspect and report on suitability, accuracy and workmanship of any manufacturer's machine in relation to a specific production requirement. He must also be able to inspect machines and equipment on arrival on site for completeness, or damage; to supervise installation and lining up, and the commissioning of machines and their tooling for specific jobs.

Three-year contract in first instance. Salary up to £2700, free housing and services, free medical attention, use of car, first class passages each way for engineer and family and other valuable advantages.

Apply stating age, qualifications, experience, family circumstances and names of references to:

Secretary
A.E.I. OVERSEAS LTD
33 Grosvenor Place, S.W.1 Z 854

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DRAUGHTSMEN

B.I.P. Chemicals Ltd., Oldbury, Birmingham, have vacancies for Draughtsmen with experience in plant layout and design including all services. The Company offers good conditions of employment and has a generous Pension and Life Assurance Scheme. Applications should be made in writing giving full details of qualifications and experience to:—

Personnel Manager
B.I.P. CHEMICALS LIMITED
Oldbury, Birmingham Z 813

'Engineering' Appointments Section

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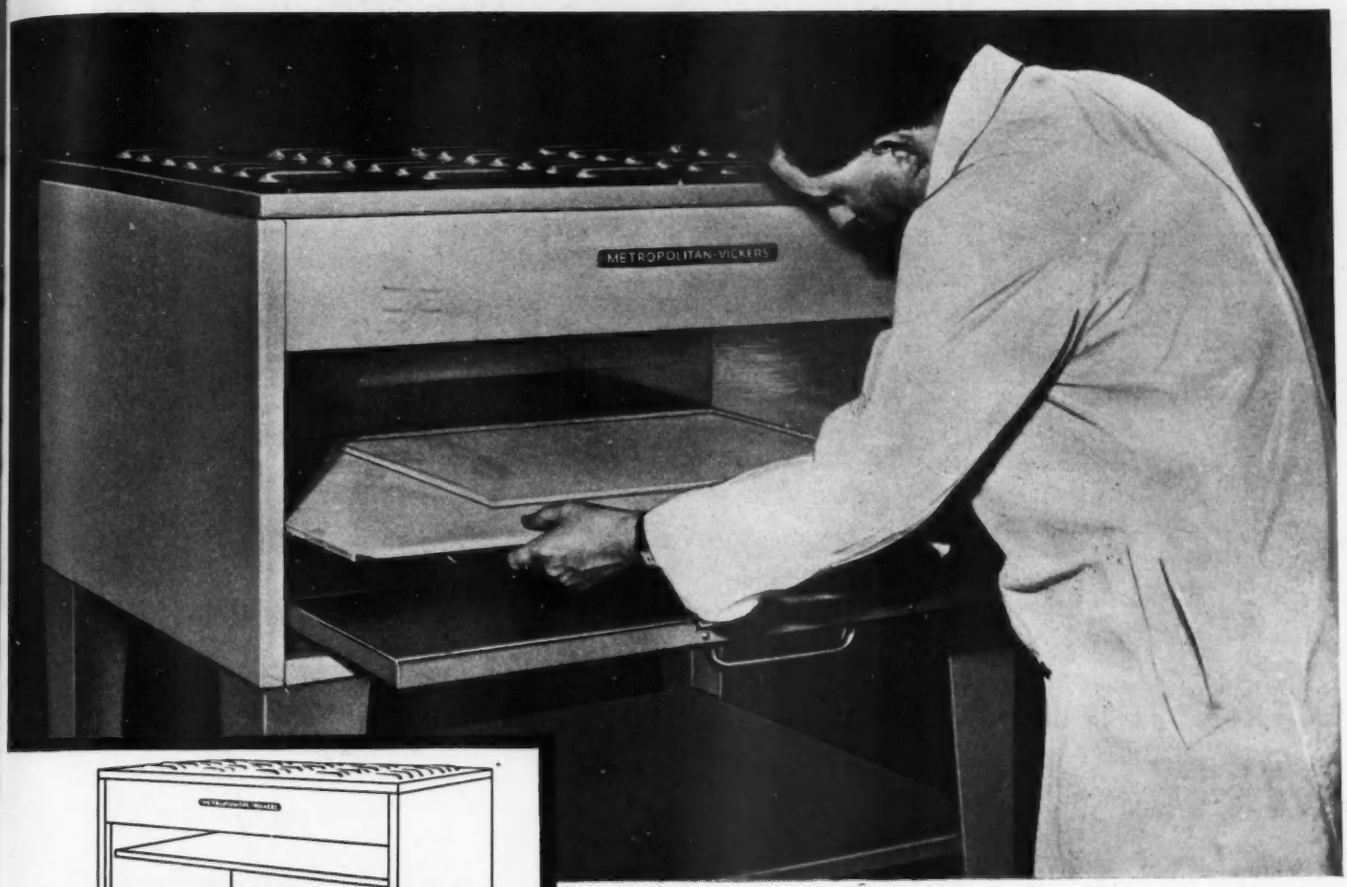

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The Metrovick type IRO/2 oven has been specially designed for the heat processing of small articles in batch production; it is especially suitable for pre-heating, paint stoving, drying of lacquer, the removal of moisture from chemicals or foodstuffs, curing and softening of plastics, and the drying and activation of adhesives.

The oven utilises the well proved Metrovick tubular sheathed heating elements, which are mounted in anodised aluminium reflectors. The unit is rated at 6kW and is suitable for use over the voltage range 400/440V, 3 phase or 230/250V single phase. Please write for further details.

METROPOLITAN-VICKERS
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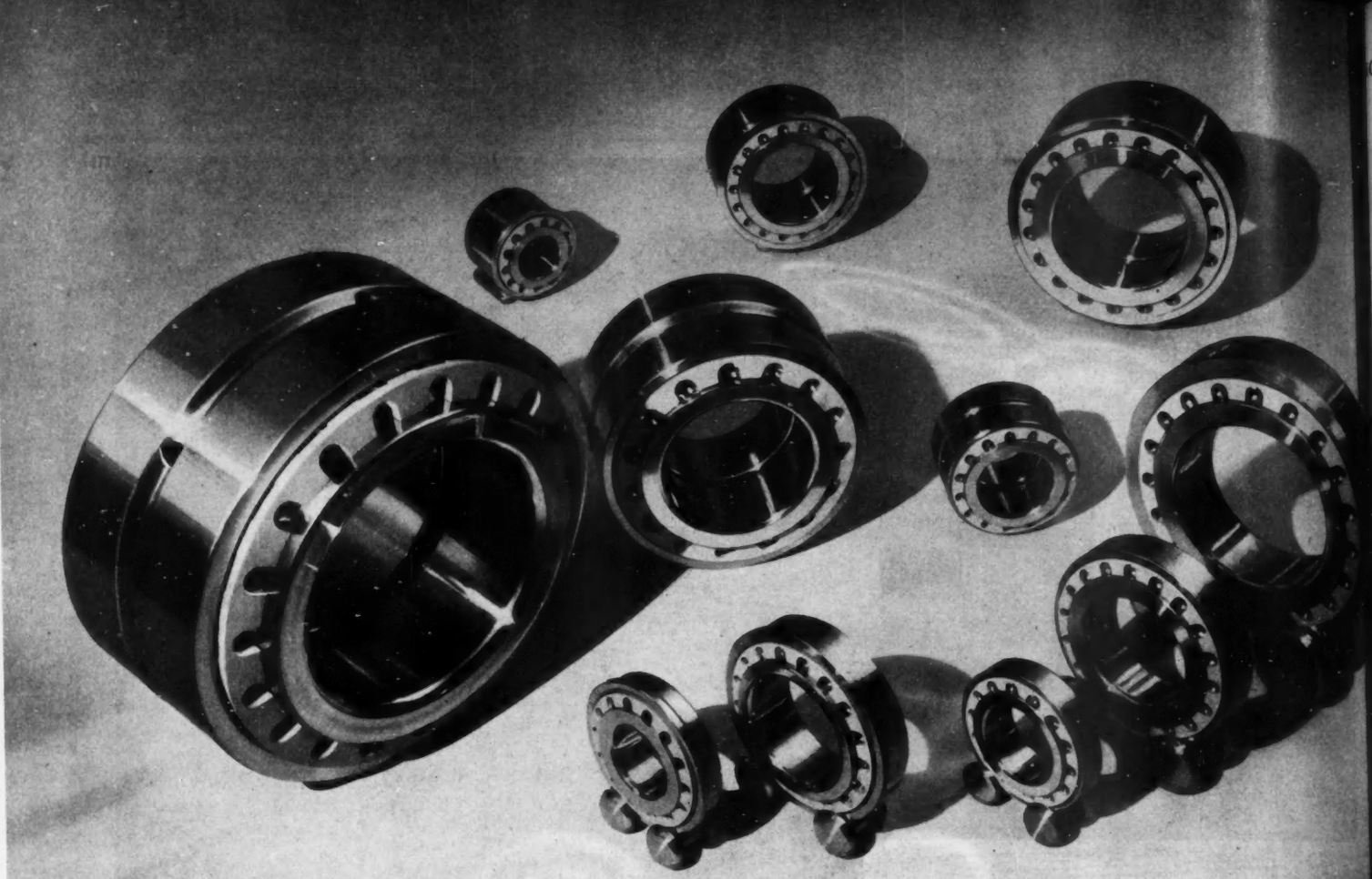

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3, 4, 5, & 6 Tons
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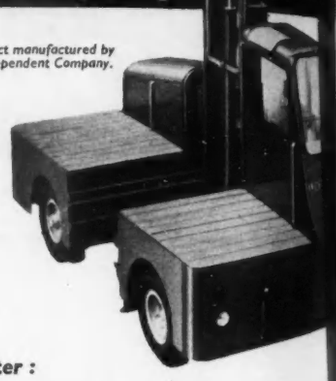

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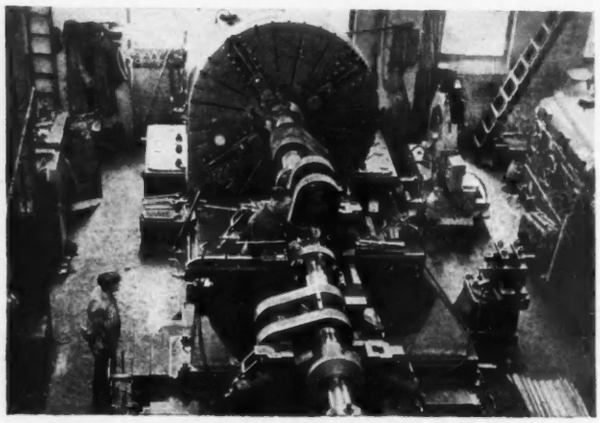

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At Newton Abbot the latest facilities are available for the complete manufacture of precision ground case-hardened gears, in either prototype or production quantities. Where special gears are not necessary, quick delivery may be made from the Centrax range of pre-designed gears. We also design and manufacture complete gear boxes.

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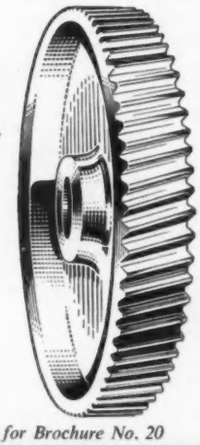

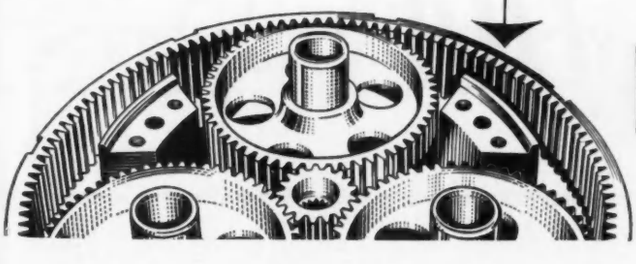

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BECAUSE research plus new design and production techniques make wood an entirely new constructional material. A material that is exciting to the designer, economical in first cost, and very low in maintenance costs.

Bowstring truss, 80 ft span, under load test at T.D.A. Research Laboratories.

This truss is a typical example of advanced design and construction in 'new era' wood. The 'tied arch' provides wide spans and is a low-cost, maintenance-free roof structure. It has high fire-endurance. Spans of up to 180 ft have been designed by T.D.A.

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We have a complete range of gauges in stock, both 4in. and 6in. dial, from 0-15 lb/in² to 0-1000 lb/in²; these are fitted in a brass case with back flange for surface mounting and with pressure connection screwed $\frac{3}{8}$in. B.S.P.

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10 to 8,000 lb/in²

This Tester is fitted with a Patent Priming Pump for easy and rapid filling. Automatic pressure changeover is obtained by a patented Dual Range Piston Unit, and the 'Ranger' is capable of a high degree of accuracy.

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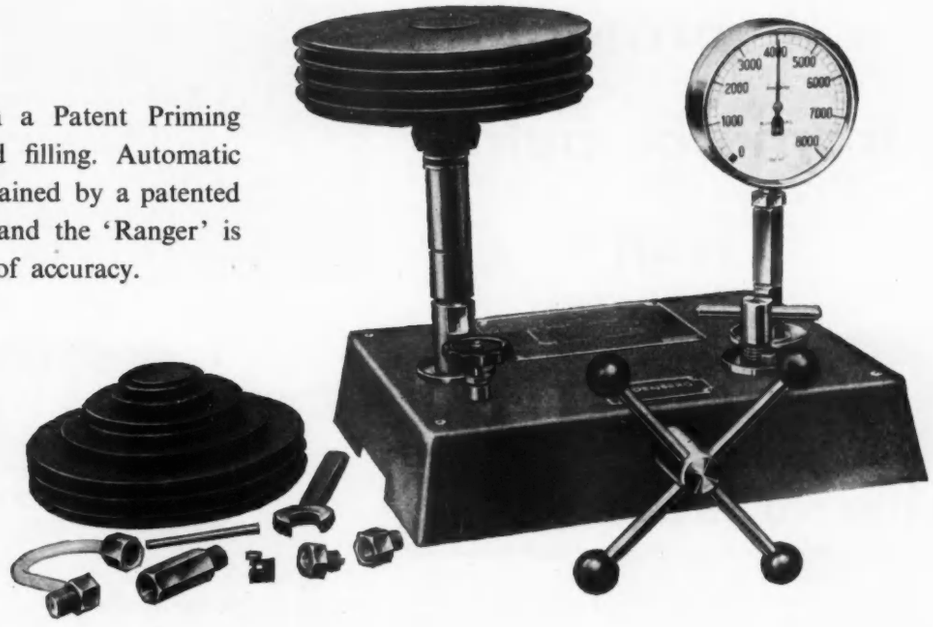

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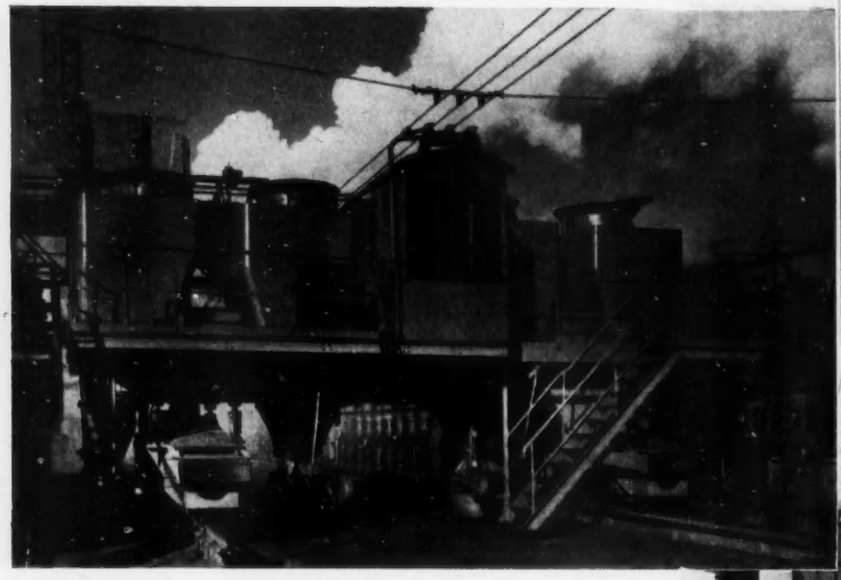
dmBU44/45.

Cranes and coking plant



Above: Coke Oven Loading Car at Manvers Main Coking Plant by kind permission of the N.C.B. North Eastern Division

Right: Crane at Dover Harbour by kind permission of the British Transport Commission, Shipping & Continental Dept.

protected from corrosion with

EVODYNE
CHLORINATED RUBBER PAINTS

OVER

EVOLED
THE PATENTED RED LEAD PRIMER

the perfect combination for corrosion protection under highly acidic and marine conditions

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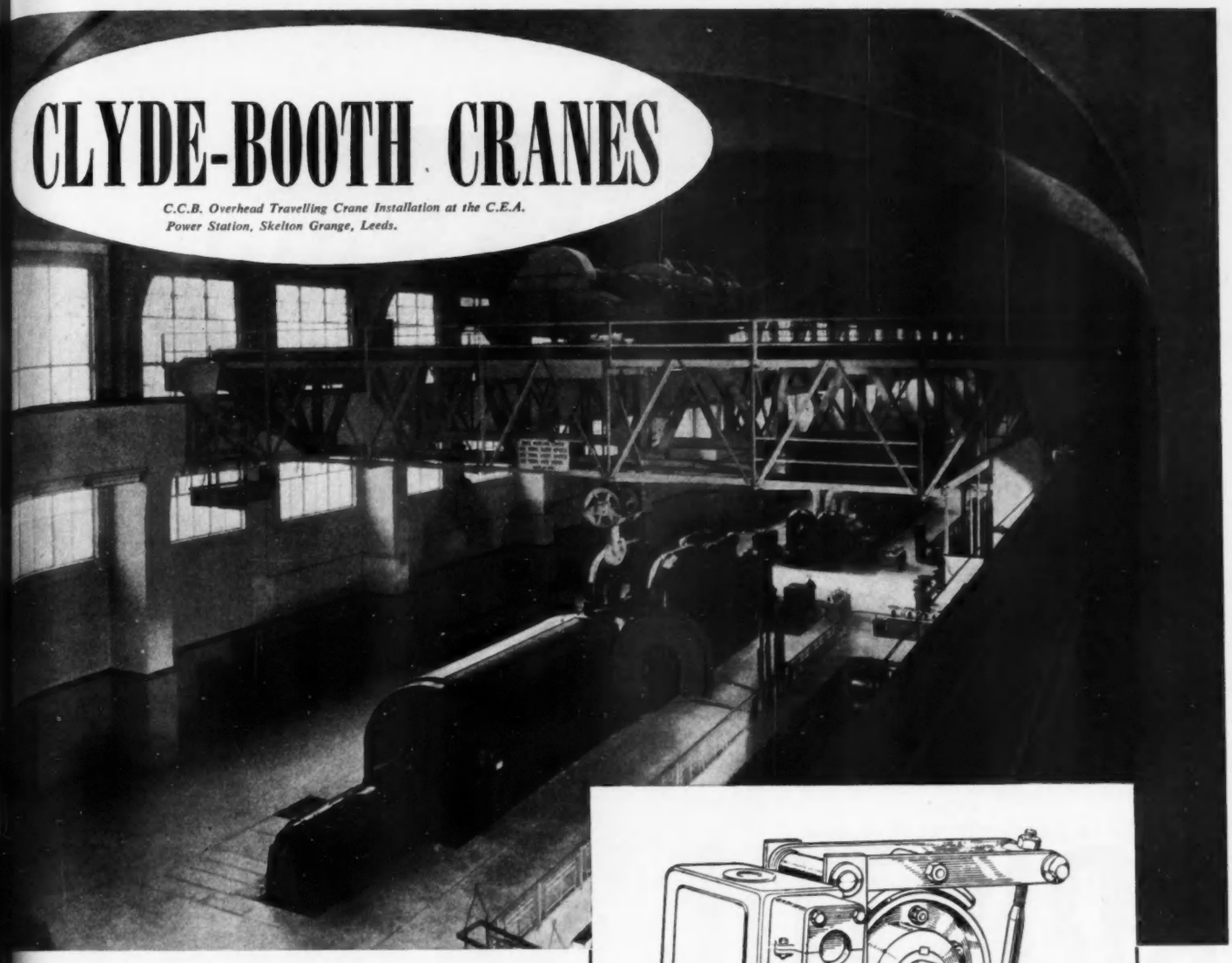
CLYDE-BOOTH CRANES

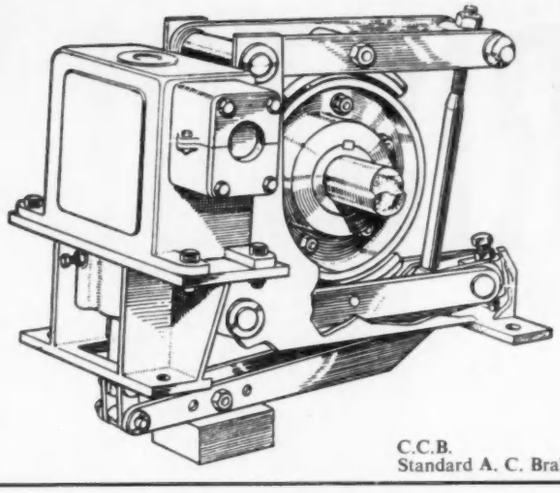
C.C.B. Overhead Travelling Crane Installation at the C.E.A. Power Station, Skelton Grange, Leeds.



lent Features of
Clyde-Booth Design . . . .

ELECTRIC BRAKES....

The C.C.B. Solenoid brake is a compact all steel design, built to give long working life with a minimum amount of adjustment. Detail refinements include:



C.C.B.
Standard A. C. Brake

- **Hardened and ground pins working in phosphor bronze bushed links.**
- **Die pressed friction linings ground to form after fitting.**
- **Quick and easy adjustment to compensate for lining wear.**
- **Wide brake drum and shoes provide large friction area.**

CLYDE BOOTH

CLYDE CRANE & BOOTH LTD. *Incorporating :*

Joseph Booth & Bros.,
Union Crane Works, RODLEY, Leeds
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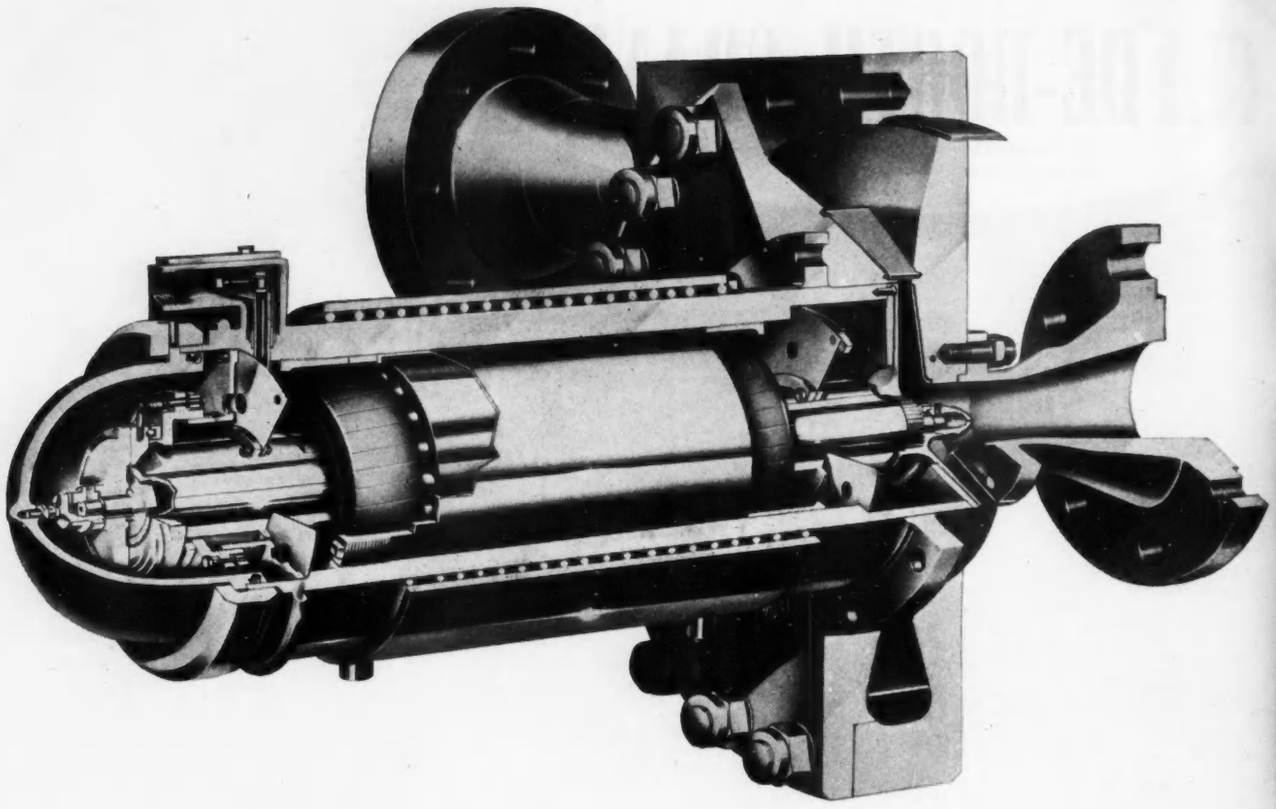
Grams: Cranes Rodley Telex
Telex: 55159

Clyde Crane & Engineering Co.,
MOSSEND, Lanarkshire
Telephone: Holytown 412 (6 lines)
Grams: Clyde Motherwell Telex
Telex 77443



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HAVE DESIGNED A RANGE OF GAS BEARING COMPRESSORS CAPABLE OF HANDLING GASES UP TO ...

2,000 psi and 700°C

with input powers up to 2,000 hp
They have many advantages
They are:
Free from lubricant contamination
Totally enclosed, needing no mechanical seals
Practically maintenance-free
Capable of operating over a wide range of temperatures and pressures

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Capacity!

Unlimited Capacity for the production of steel Double Helical Gears, whether hobbed, milled or plano-generated and up-to-date plant and metallurgical facilities, coupled with a century of technical experience, have built up the "JACKSON" reputation that is your safeguard.

Large machine cut double helical gears for colliery winder.

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SALFORD WORKS HAMPSON STREET
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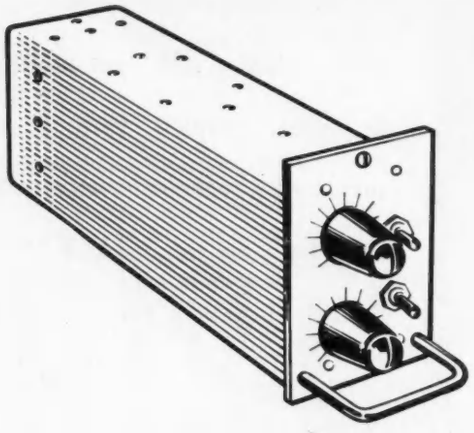
A.W.A ELECTRONICS

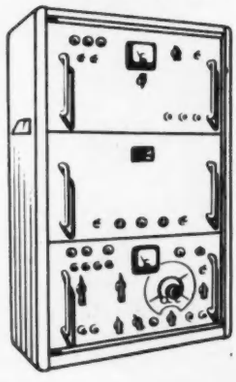
New concepts in electronics have been developed at AWA, as a result of experience with missile systems. Now they have a wider application. Here are some of the new AWA devices now available to industry.

TRANSISTOR GALVANOMETER AMPLIFIER



This Amplifier has been designed to drive viscous damped recording galvanometers which normally have a resistance of 50 ohms and a working range of D.C. to 2 Kc/s in frequency. The amplifier has a switched attenuator at its input and will accept single ended or push pull signals from ± 1 Millivolt to ± 500 volts and will feed a maximum of ± 50 Milliamps to the galvanometer. There is also a range of ancillary units available for use with this Amplifier as part of a comprehensive instrumentation system. *Standard specification: Dimensions: 4¼ in. x 3¾ in. x 10 in.; Frequency response: Flat from DC to 2 Kc/s, 5% down at 3 Kc/s, 3db down at 6 Kc/s; Noise level: less than 10 Microvolts; Input impedance: 40,000 ohms on range 5, 110,000 ohms all other ranges; Gain: Maximum 7·5 Milliamps/Millivolt, minimum 0·04 Milliamps/Volt; Power requirements: ± 6 Volts D.C. 220 Milliamps each line.*

COMEL 8 & 12 SWEEP OSCILLATOR AND VIBRATION CONTROLLER



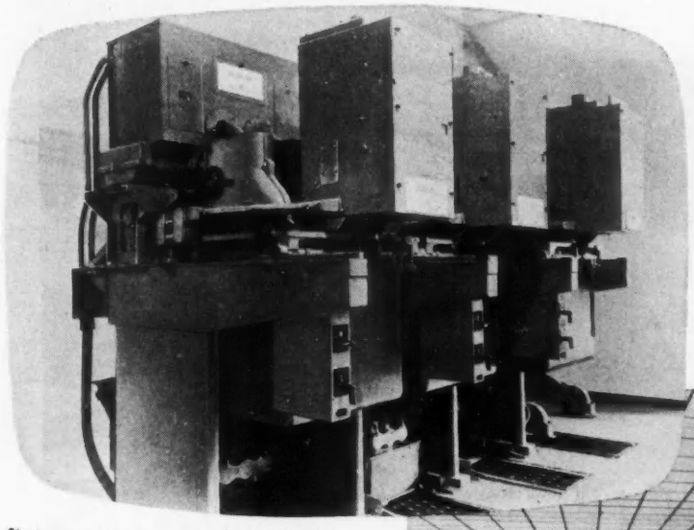
This unit is designed to drive vibrator amplifiers and has a wide frequency range. The sweep speed is variable over a range 12:1 and automatic frequency sweep facilities are provided. *Frequency Range: 10 c.p.s. to 32 Kc/s in ranges of 5 octaves each. There are 7 switch speeds ranging from 5 secs./octave-60 secs./octave. Variety of Outputs available. Vibration Controller: Input: 4V r.m.s. at appropriate frequency. Output: Up to 100 mV r.m.s. into 600 ohms. Pick Off: Sensitivity 10 mV r.m.s. per "g" peak. Overall Dimensions: 35" x 22" x 14". The Vibration Controller will control ± 40 "g" or as determined at low frequencies by the excursion of the vibrator table.*

All devices are adaptable to suit customers' own requirements. For further information consult:

COMMERCIAL ELECTRONICS DEPT.

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD., Baginton, Coventry

MEMBER OF THE HAWKER SIDDELEY GROUP



generator switchgear at Calder Hall

Photographs by courtesy of the U.K.A.E.A

The generators at the Calder Hall Power-station of the Atomic Energy Authority are controlled by Reyrolle 11-kV 500-MVA and 750-MVA switchboards and their associated control-boards

Reyrolle equipment is also installed at:

Capenhurst,

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Reyrolle

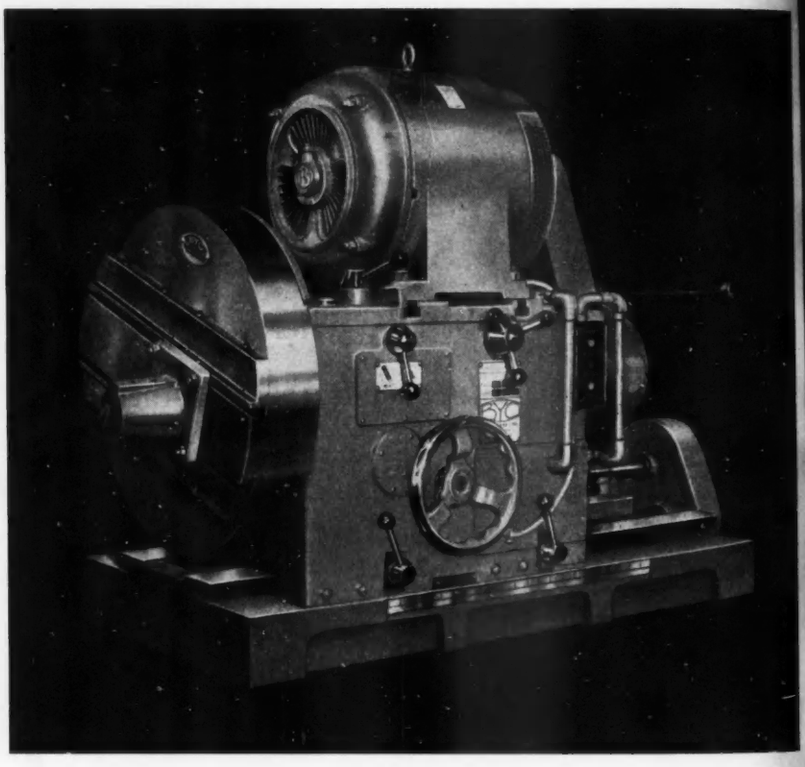
A MEMBER COMPANY OF THE NPPC NUCLEAR POWER PLANT CO. LTD.

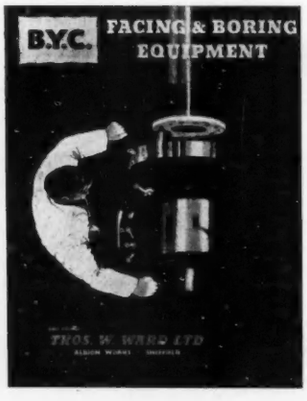
A. REYROLLE & COMPANY LIMITED, HEBBURN, COUNTY DURHAM, ENGLAND

b.y.c.

B.Y.C. BORING & FACING EQUIPMENT

Capable of replacing conventional type machines, particularly on pipe flanges, valve bodies, and numerous applications in shipyards, steelworks, etc. A range of fully automatic units is also produced.





Send for Your Copy Now!

This new brochure gives full details of the standard units, automatic units, and patent facing heads for fitting to existing machines.

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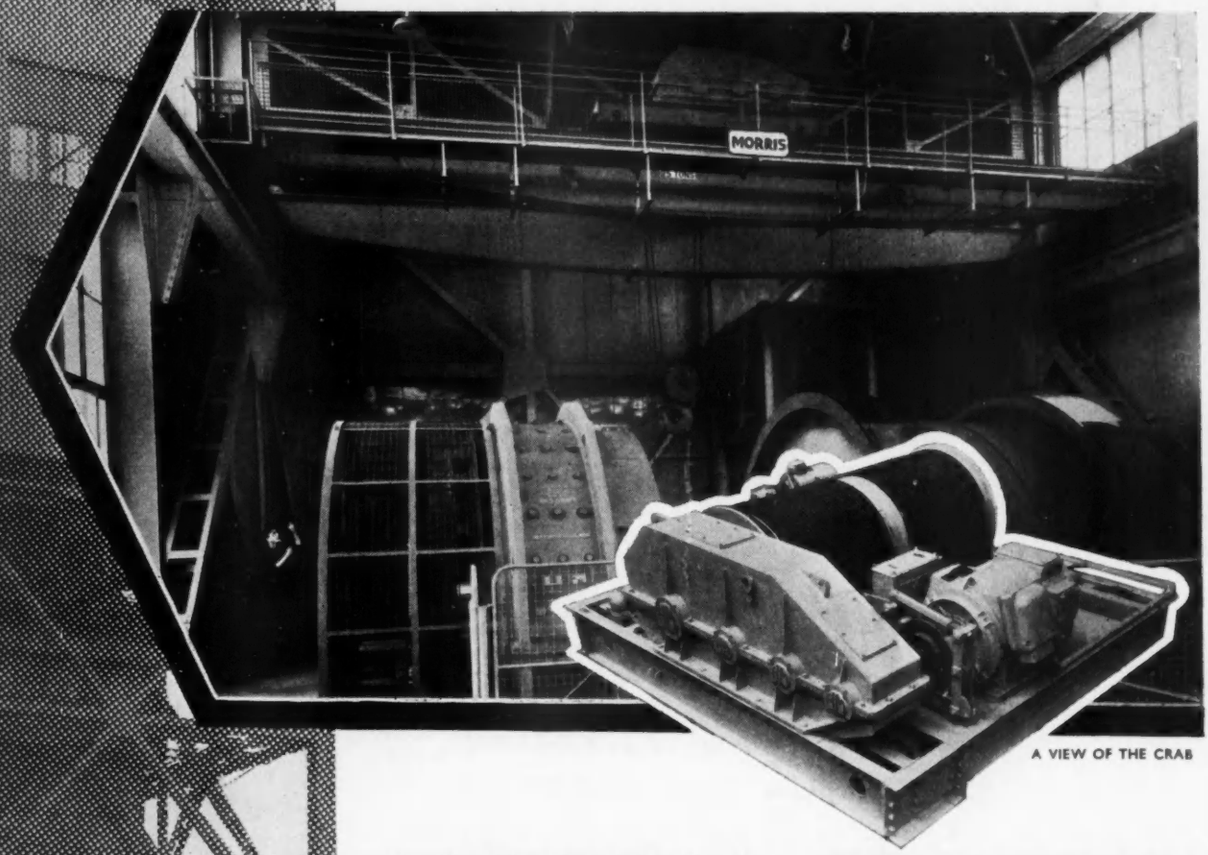
RIGHT ON TOP



A VIEW OF THE CRAB

MORRIS CRANES

match the N.C.B's modern outlook

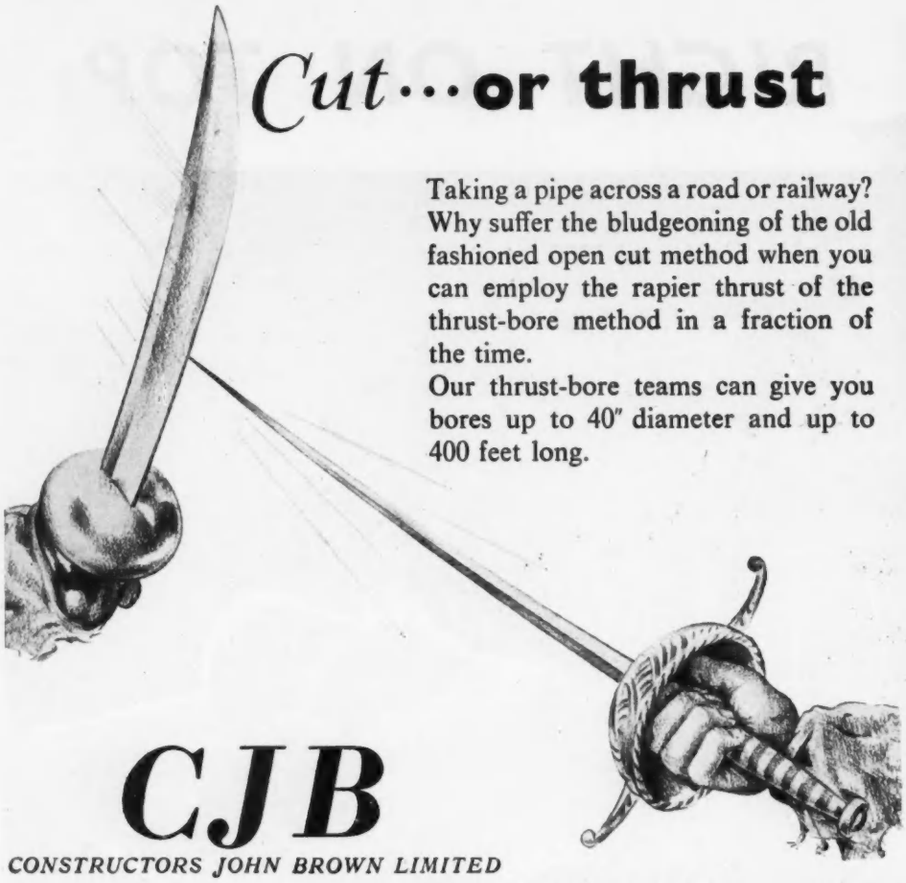
FOREMOST FOR SAFETY SINCE 1884

Right at the top of this combined colliery pit headgear and winding house (known as a Koepe tower) is a 25-ton Morris Electric Crane installed as an essential maintenance feature. There are more than a dozen Morris Cranes installed in similar towers at collieries in other parts of the country.

Thus do the National Coal Board (in line with many organisations which have become a household word) choose Morris cranes for vitally important duties. They know that immense experience both in design and application goes to the making of Morris cranes, and not only that of the Morris Company itself, but that of its associate Companies also, for there are few overhead crane application problems which have not been met and mastered by Morris engineers.

HERBERT MORRIS LTD P.O. Box 7 LOUGHBOROUGH ENGLAND.

Cut···or thrust



Taking a pipe across a road or railway? Why suffer the bludgeoning of the old fashioned open cut method when you can employ the rapier thrust of the thrust-bore method in a fraction of the time.

Our thrust-bore teams can give you bores up to 40" diameter and up to 400 feet long.

CJB horizontal Thrust-boring unit at work putting pipelines under rail without any interruption to tra

CJB

CONSTRUCTORS JOHN BROWN LIMITED

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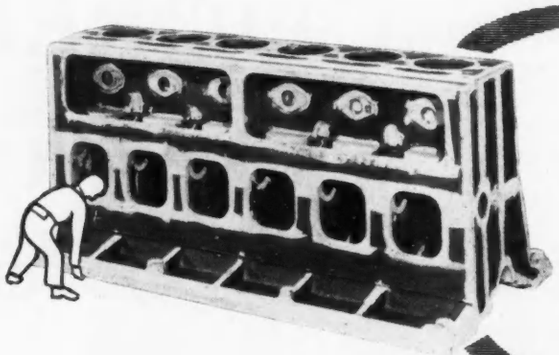
HEAVY castings

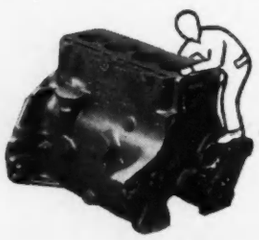


Well, heavier than we have previously supplied. We have increased our capacity in the floor moulding department and can now supply castings up to 5 tons weight in grey iron, and up to 2 tons weight in aluminium alloy.

These have been our speciality for many years. Let us examine your casting problems.

We supply grey iron castings made in green sand, dry sand, and by the shell moulding process.

Our aluminium foundries use the green sand, gravity die, pressure die and plaster processes.



Intricate castings

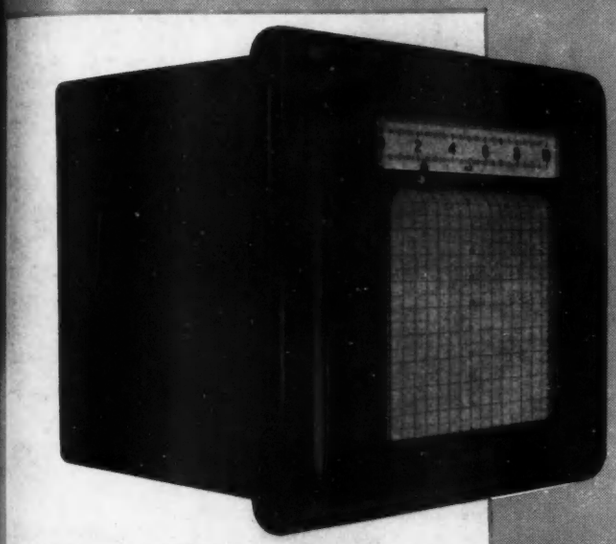
CAST WELL & TRUE *for quantity supply*

West Yorkshire Foundries Ltd.

SAYNER LANE, LEEDS 10
Telephone LEEDS 29466

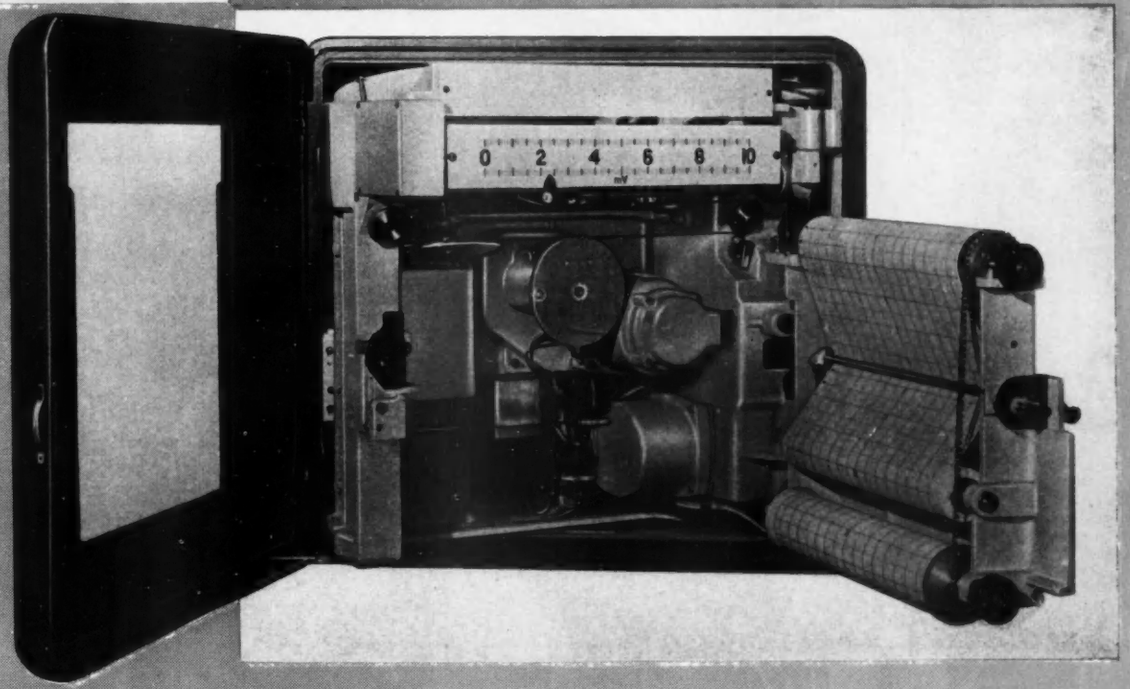
London Office:
HANOVER HOUSE, HANOVER SQ., W.1
Telephone MAYfair 8561

Announcing the *mark 3 multelec* electronic strip-chart recorder



Features include

- Electronic system and components as used in other KENT instruments
- All-mains operation—no batteries—with continuous standardization
- Availability in 2-, 3-, 4-, 6-, 8-, 12- and 16-point form
- 2-second full-scale travel—deadbeat balancing eliminating " overshoot "
- Chart-speed variable between 1 in./h and 4 in./min
- Multi-point printing intervals of 5, 10 or 20 seconds, depending on application
- High-gain amplifier, with extremely sensitive synchronous converter



Mark 3 Multelec *recorder, showing the chart frame swung away to allow ready access to the main-frame components; plug-in amplifier, etc. is easily reached by swinging forward the main frame*

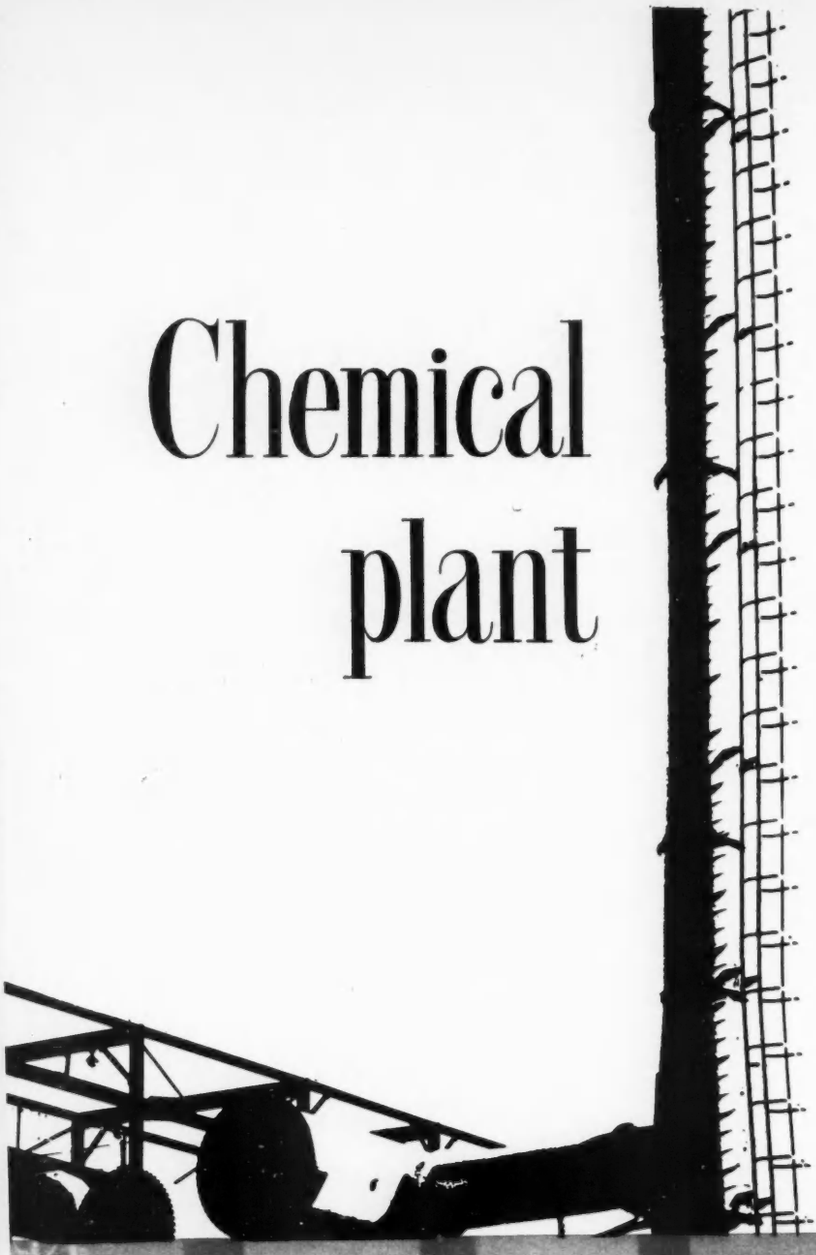
KENT masters of instrumentation

Write for Publication 295, *or telephone Engineering Industry Contracts Dept. (Luton* 2440, *Ext.* 191) *for a quotation*

GEORGE KENT LIMITED · LUTON · BEDFORDSHIRE · ENGLAND

Factories, Subsidiary Companies, Branch Offices, and Representatives in most countries

Chemical plant



by Simon-Carves Ltd

Here we show a few of the many plants designed and built for the chemical industry in recent years. These include plants for sulphuric acid production, recovery and concentration; plants for sulphur recovery; complete gasworks by-products plants and electro-precipitation plants for the removal of tar fog, acid mists, pyrites dusts, boiler flue dusts and other industrial dusts. All these are just a part of the service we are providing for the chemical industry.

1 This general view of the electro-precipitation plant built for the United Sulphuric Acid Corporation at Widnes shows the South Battery of tail gas mist precipitators in the foreground.

2 At the Central Electricity Generating Board's Willington 'A' power station, Simon-Carves are installing four sets of these twin-flow boiler flue dust precipitators.

3 These coal dust precipitators were installed at the National Coal Board's "Phurnacite" plant at Aberaman. An efficiency of 99·93% was obtained in the official acceptance tests.

4 Type of Plant: Contact Sulphuric Acid.
Raw Material: Sulphur.
Rated Output: 175 tons per day.
Client: Laporte Titanium Limited.
Location: Stallingborough, Lincs.

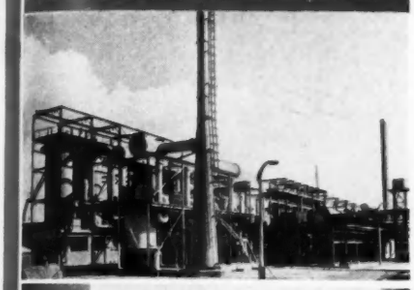
5 Type of Plant: Contact Sulphuric Acid.
Raw Material: Sulphur.
Rated output: 175 tons per day.
Client: Scottish Agricultural Industries Limited.
Location: Leith.

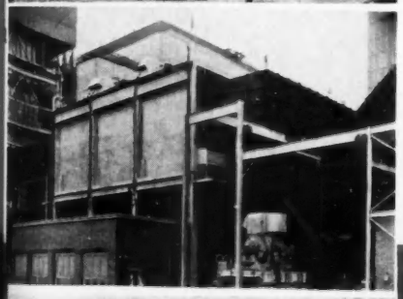
6 Type of Plant: Sulphuric Acid Concentration.
Output: 100 tons per day H_2SO_4 from 45% to 95%.
Client: British Hydrocarbon Chemicals Limited.
Location: Grangemouth.

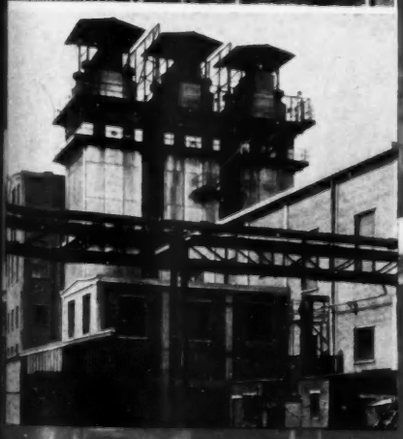
7 Type of Plant: Contact Sulphuric Acid.
Raw Material: Pyrites.
Client: African Explosives & Chemical Industries (Rhodesia) Limited.
Location: Rodia, S. Rhodesia.

8 This two-stream gas detarring and ammonia washing plant has a capacity of 12 million cubic feet a day. It was built at the New Wortley gasworks for the North Eastern Gas Board.

9 Built at the Stapleton Road Gas Works of the South Western Gas Board, this concentrated ammonia liquor plant has a capacity of 1,800 gallons per hour of crude liquor.







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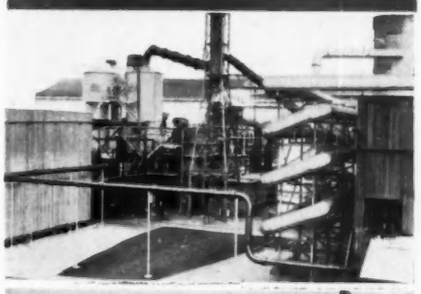

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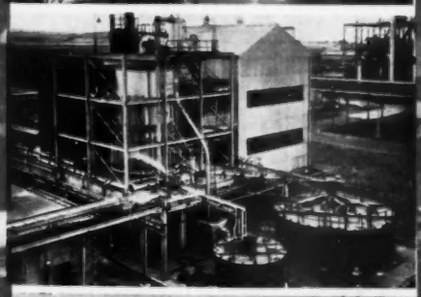

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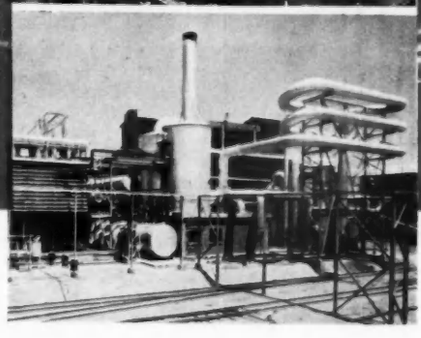

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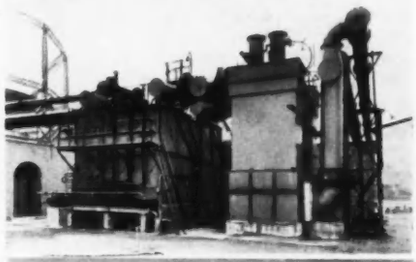

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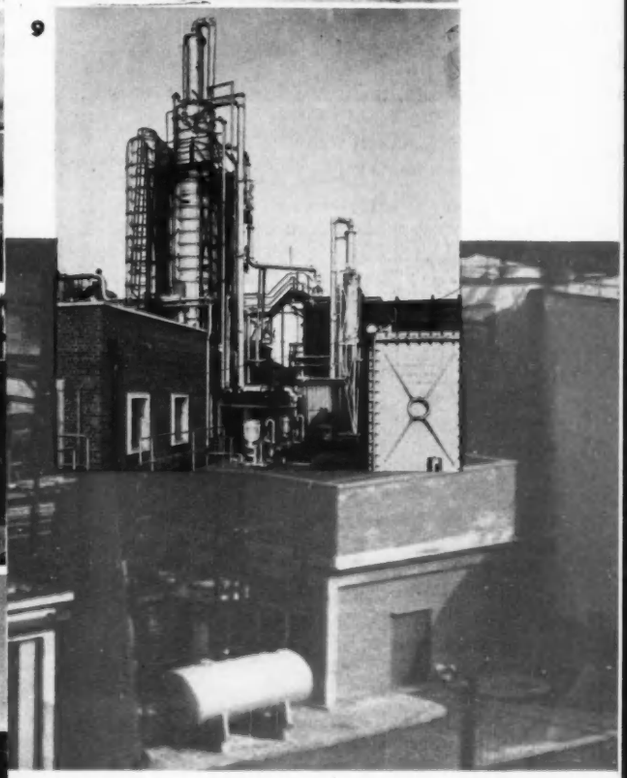
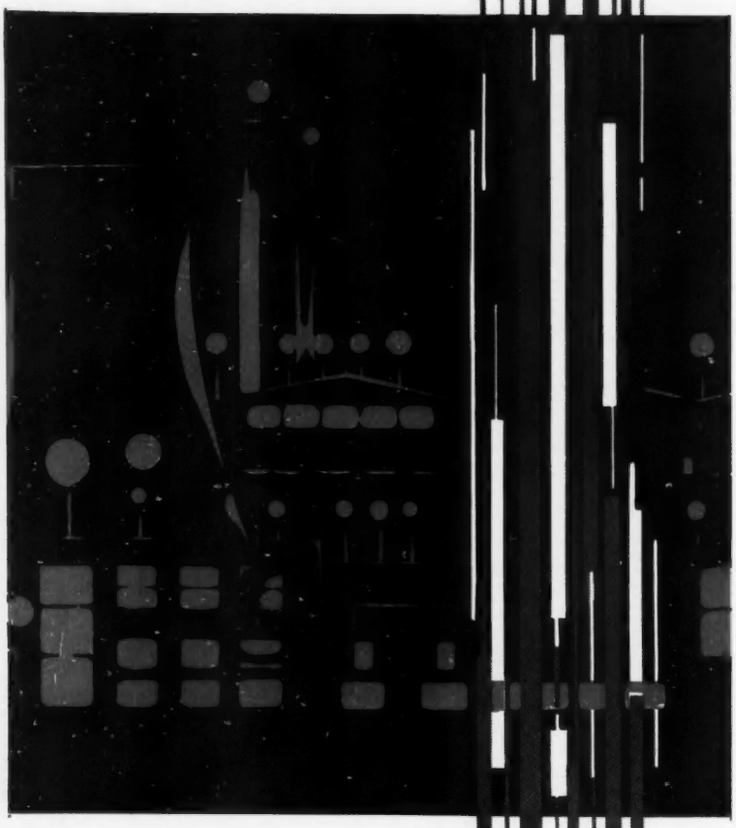


RVICE TO THE CHEMICAL INDUSTRY BY *Simon-Carves Ltd*

SIMON ENGINEERING GROUP

STOCKPORT, ENGLAND

I.C.I.
CARBON DIOXIDE GAS FOR INDUSTRY



I.C.I. supplies industry with high purity carbon dioxide in two forms:

For large users—

I.C.I. LIQUID CARBON DIOXIDE IN BULK is the cheapest method of buying carbon dioxide. There are no losses of residual gas, handling charges are eliminated, adequate stocks are easily maintained. Storage tanks of five-ton capacity are supplied by I.C.I. complete and ready for use, and I.C.I.'s rapid delivery service of liquid carbon dioxide means that vital work is never delayed.

For smaller users—

'DRIKOLD', solid carbon dioxide, and the 'DRIKOLD' LIQUEFIER give gas under pressure and ready for use. Only the net weight of carbon dioxide is handled—there's no heavy equipment to be lifted or moved. Once liquefiers are installed, pipelines remain connected—there is no coupling and uncoupling of lines. The liquefiers—usually supplied in pairs, to ensure continuity of gas supply—are simple to operate and each can give a discharge rate ranging from 8 cu. ft per minute to 70 cu. ft per minute. 100 lb of 'Drikold' will produce 875 cu. ft of gas measured at atmospheric temperature and pressure.

For both—

FULL TECHNICAL SERVICE is available. Help in the operation and maintenance of equipment and advice on all carbon dioxide problems is readily given.

Full information on request.

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

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cleaner sharper reproductions

Get perfect 'originals' and first-class prints with TURQUOISE pencils. Extra smooth TURQUOISE pencils actually ease your work! TURQUOISE lead lasts longer for every sharpening. Holds a needle point under great pressure. It's made from 100% electronic graphite to give denser, more opaque lines for cleaner, sharper reproductions. Lines rub out without a trace as required. No omissions, no fade-outs, no 'ghost' lines on your prints! 17 precise gradings from 9H to 6B.

ALSO AVAILABLE!
Turquoise drawing leads 2B to 6H

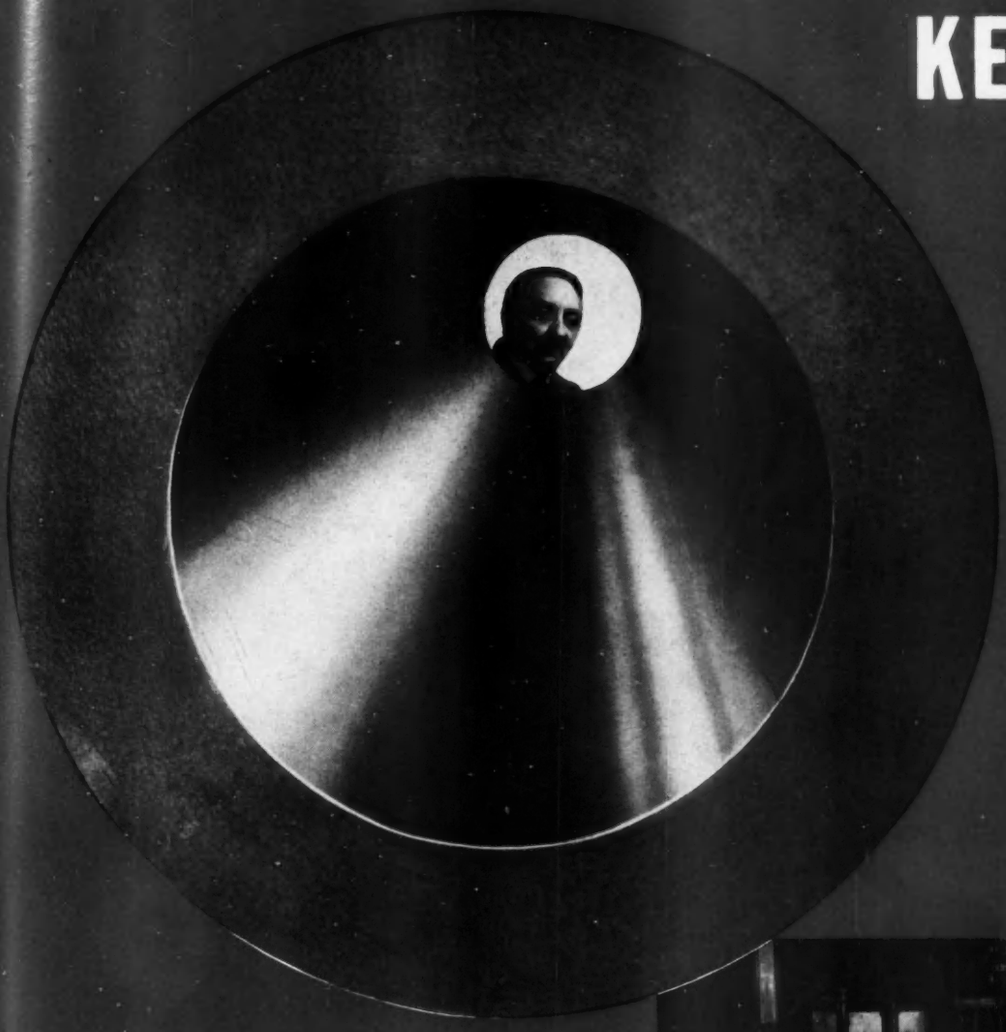
every time with

TURQUOISE pencils

9d each
8/6 per dozen

EAGLE PENCIL COMPANY, ASHLEY ROAD, TOTTENHAM N.17

Finished boring and honing from KEETONS



To save you the trouble and expense of further machining, Keetona Hollow Bored Bars are now available finished bored or honed, cut to exact length, proof-machined or shaped on the outside diameter. Keeton's special plant will produce finished bores of $\frac{3}{4}$" to 10" diameter to a tolerance of ± ·003", while bores of 2" to 8" diameter can be honed to a tolerance of ± ·001". Keetona finished or honed bars can be supplied to maximum lengths of 15 feet (dependent on size of bore) and are normally rough turned on the outside. Full details of these Keetona hollow bored bars will be found in the new illustrated brochure. Please write for your copy.

Keetona hollow bored bars were used in the hydraulic equipment produced by Samuel Hodge & Sons Ltd. for the dock gates at Penang Harbour.

TRADE KEETONA MARK

HOLLOW BORED BARS

KEETON SONS & CO. LIMITED

KEETONA WORKS, GREENLAND ROAD, SHEFFIELD 9. TEL: SHEFFIELD 43961/4

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Wherever power is used Crofts Gearboxes play a vital role . . .

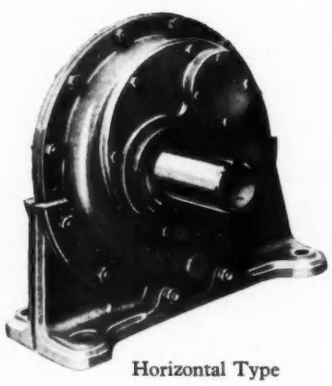
Crofts (Engineers) Limited, Thornbury, Bradford 3, Yorkshire

Crofts Shaft Mounted Gear Units

Send for Publication 157/L

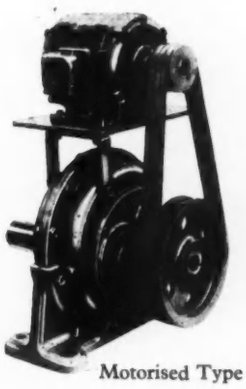
- **Fractional to 120 h.p. output speeds from 8 to 425 r.p.m.**
- **Mount direct on the driven shaft.**
- **No flexible couplings, slide rails or alignment problems.**
- **Ideal for horizontal, vertical or inclined shafts.**
- **Available with platform mounted motor, also variable speed drive.**
- **All sizes available from stock.**
- **All gears are single helical and cut from nickel-chrome alloy steel.**

AND THE UNIDAPTOR RANGE



Horizontal Type

Vertical Type



Motorised Type

Single Reduction up to 118 h.p. Double Reduction up to 88 h.p. Publication 157/L

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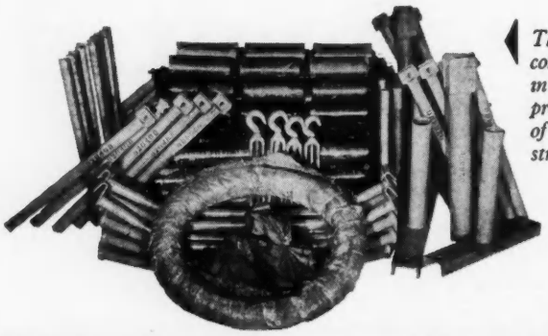
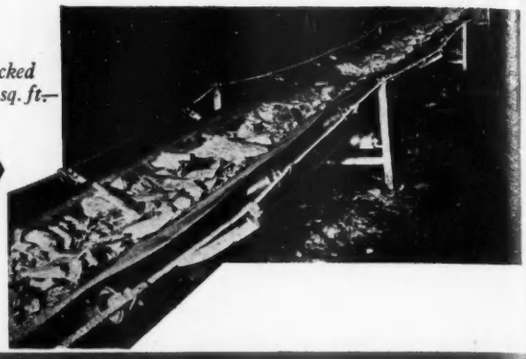


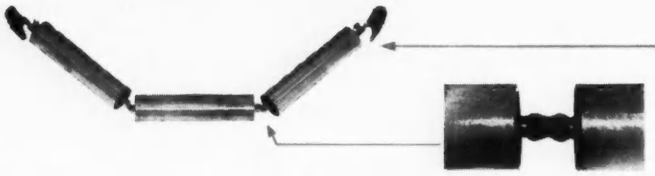
This group of components—stacked in an area of 28 sq. ft.—produce 200 ft. *of this conveyor structure . . . .*



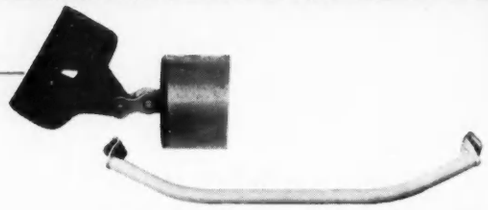
DISTINGTON-GOODMAN

ROPE BELT

CONVEYOR STRUCTURE
patented



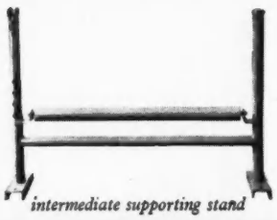
'swivel links are fitted at each end of an idler shaft



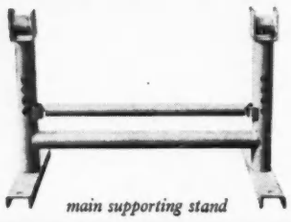
stretchers are used at intervals between stands

RESILIENT

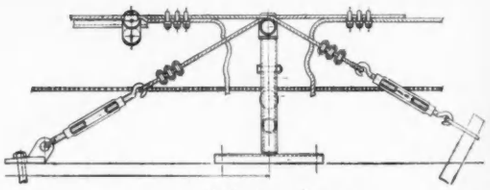
- *increases belt life*
- *reduces installation costs*
- *increases capacity*
- *almost eliminates spillage*
- *inexpensive*



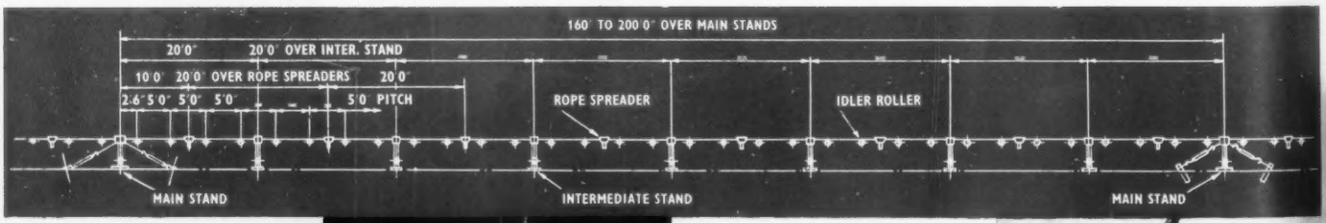
intermediate supporting stand



main supporting stand

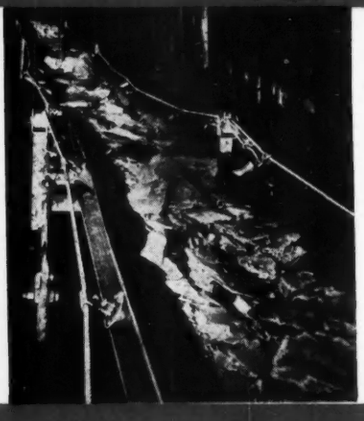


typical rope anchorages



Installation, extension and contraction of Distington-Goodman Rope Belt Conveyor Structure is relatively quick and easy.

(Right) Detail of a main stand and anchor point. These can be spaced up to 400' apart according to requirements.



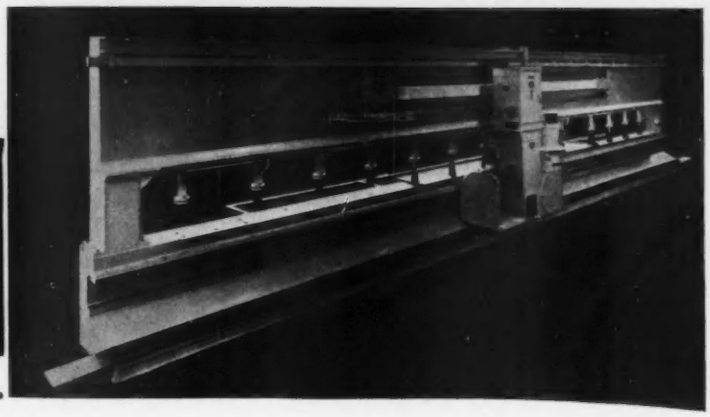
A 36" rope belt conveyor installed at a quarry, carrying 500 tons of gravel per hour. By securing the rope to terminal pulleys it has proved practicable to move this conveyor bodily sideways by the dragline shown in the illustration.

DISTINGTON ENGINEERING COMPANY LIMITED
WORKINGTON CUMBERLAND ENGLAND

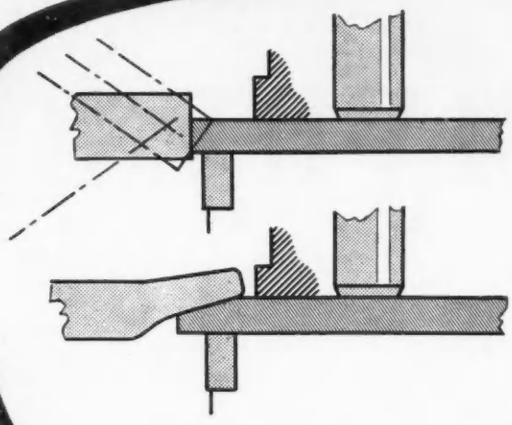
DISTINGTON

BC9

PLATE EDGE PLANING AND ROTARY SHEARING



JACK TYPE CLAMPING MACHINE



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BEAM TYPE CLAMPING MACHINE

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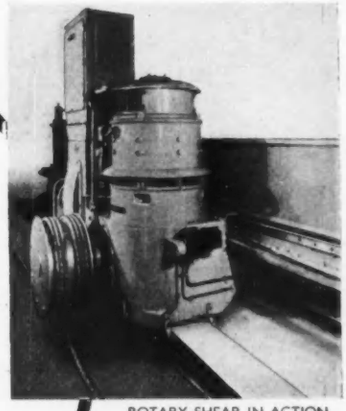
The Tru-edge Planer can be supplied with a rotary shearing head mounted on the saddle; this is capable of shearing strips up to 1¼in. wide from ⅜in. mild steel plate with an accuracy of 0·01in. in 40 feet. Its operation is about forty times faster than gas cutting, and less expensive.



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The Contract for the Atomic Power Station to be built at Trawsfynydd in North Wales has been awarded by the Central Electricity Generating Board to

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This latest Atomic Station will feed into the national grid 500,000 kilowatts of electricity.

The whole of the generating plant for Trawsfynydd, comprising the steam turbo-alternators with the condensing plant and feed-heating systems, and the blowers to circulate the hot gas through the reactors, will be built by

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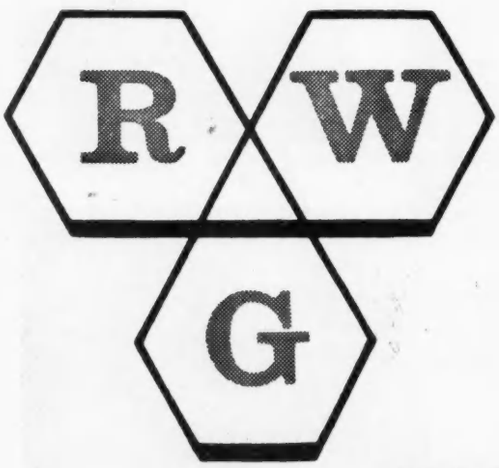
A MEMBER OF ATOMIC POWER CONSTRUCTIONS LIMITED



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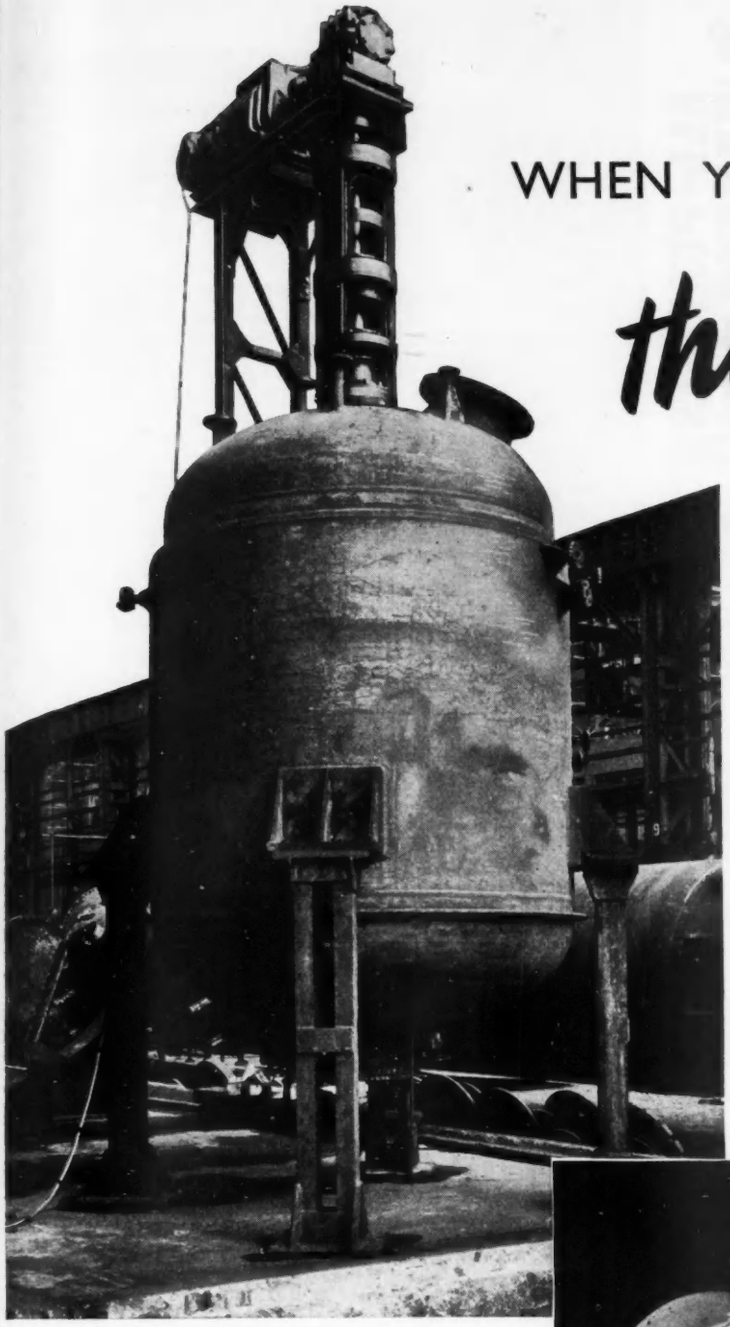

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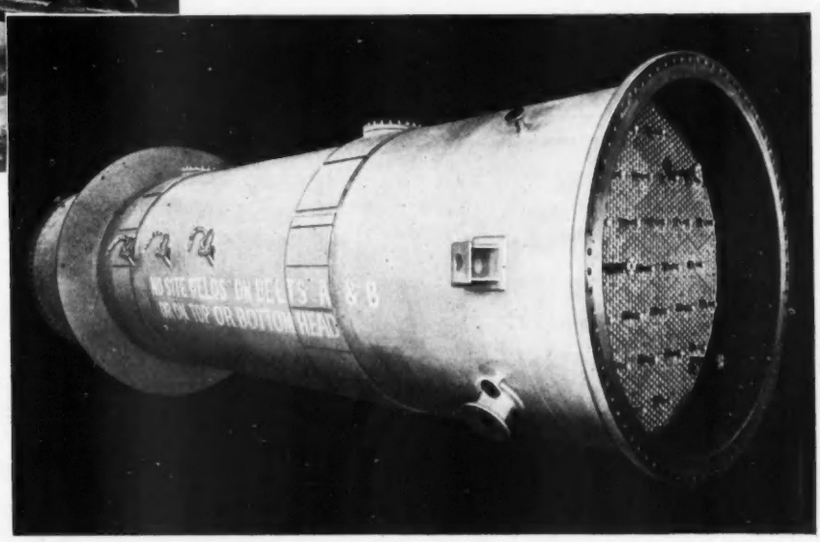
Left:
A mild steel jacketed Autoclave to Class I construction with electrically driven stirring gear.

Below:
This Ethylene Oxide Reactor weighs 135 *tons, is* 9*ft.* 6*ins. in diameter and contains over* 15 *miles of* 1¾*in. dia. catalyst tube.*



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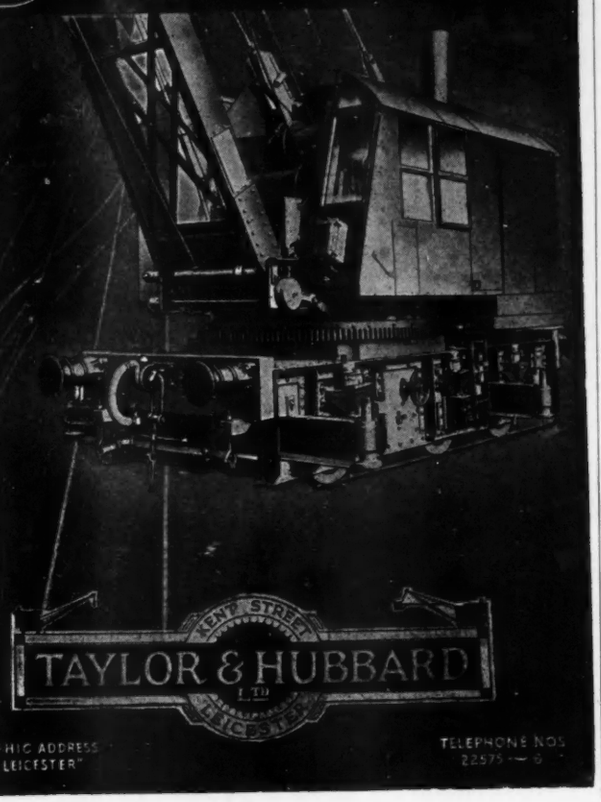

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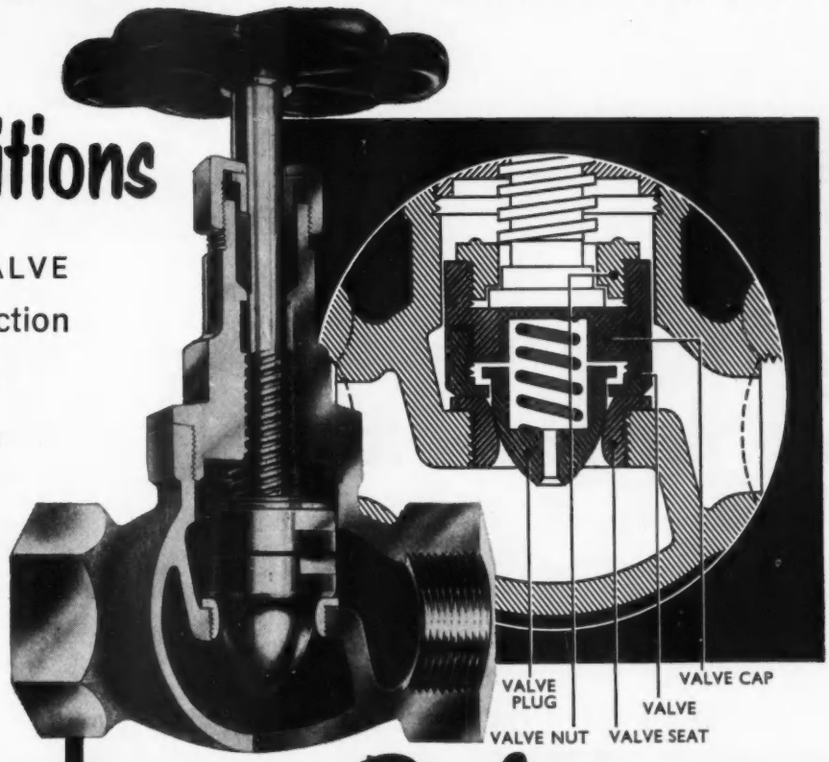

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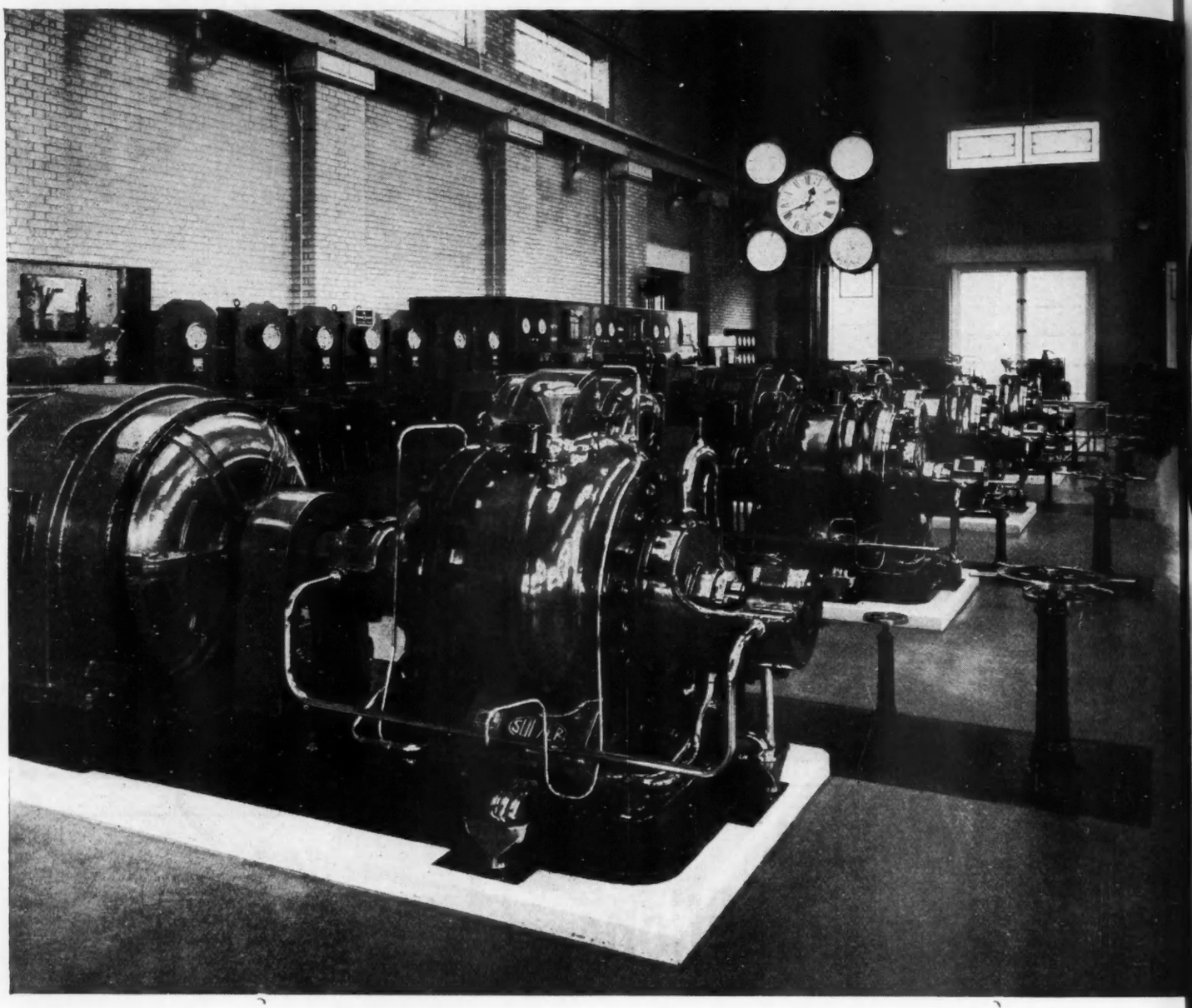

Seedy Mill Pumping Station of the Sou
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R. A. Robertson, Esq., B.Sc., M.I.C.E. Engineer-in-Ch
The illustration shows seven of the fourte
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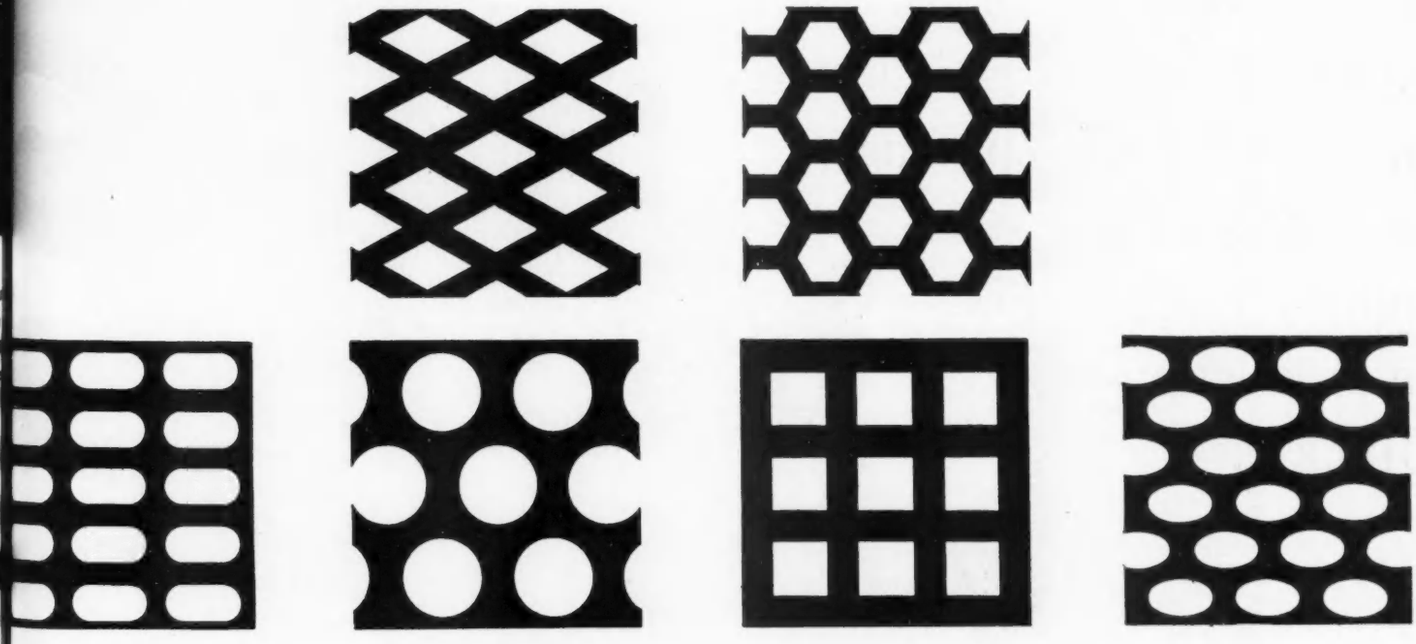

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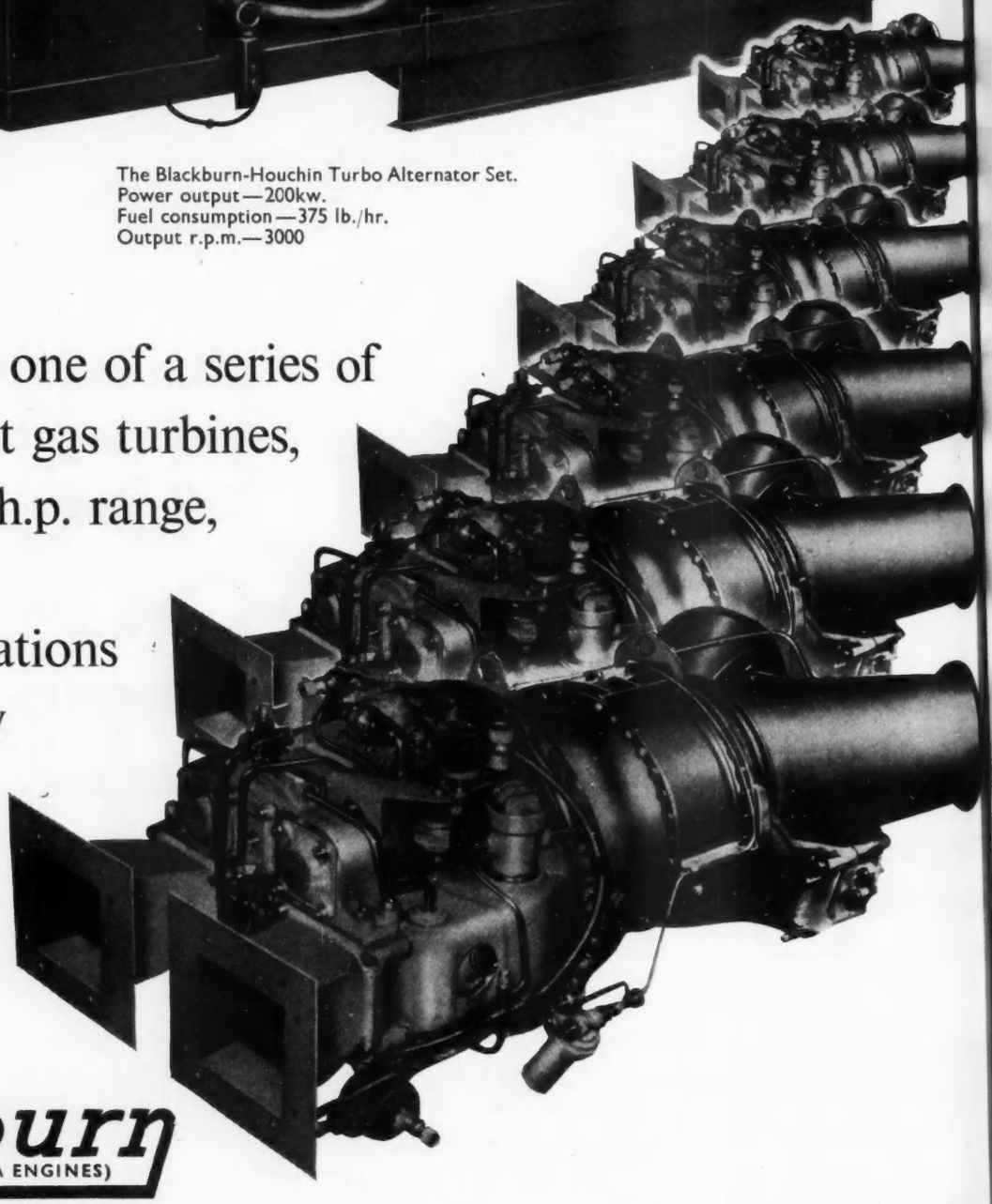

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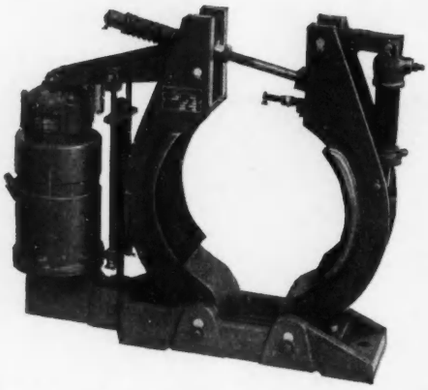

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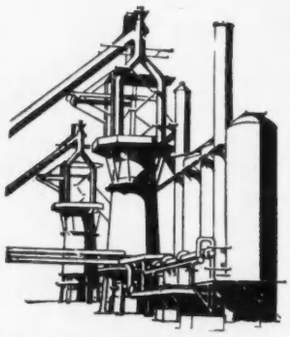

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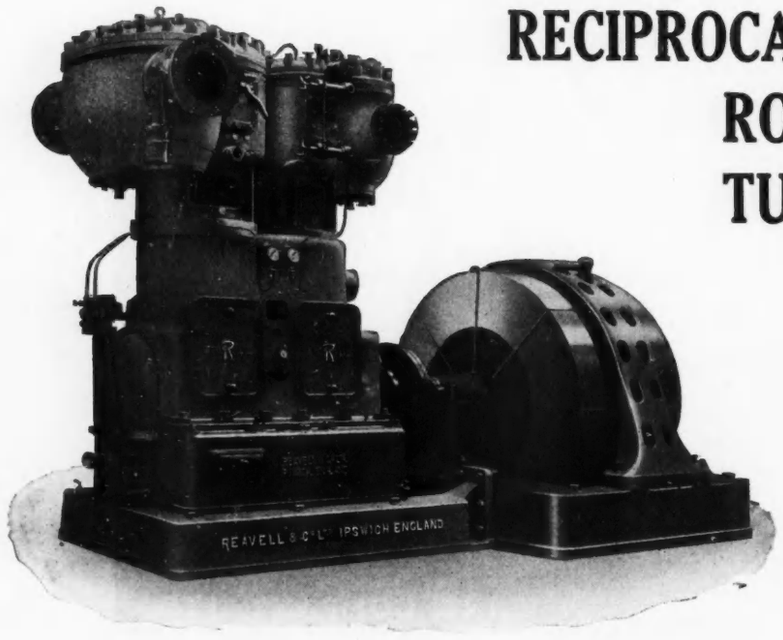

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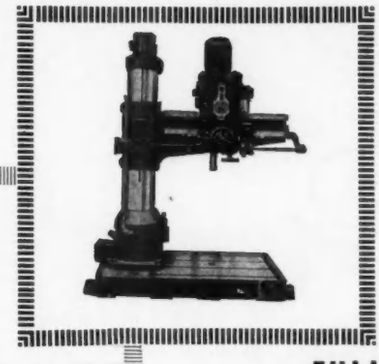

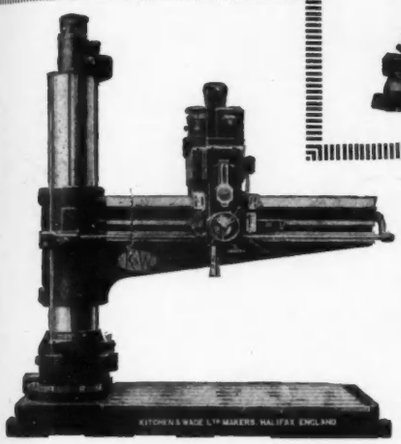

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The illustration shows an interlock guard in use on a hydraulic press producing engine components.

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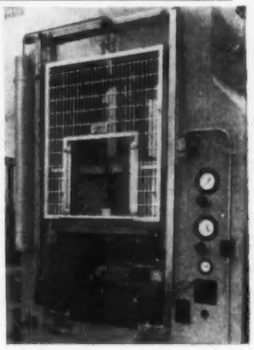

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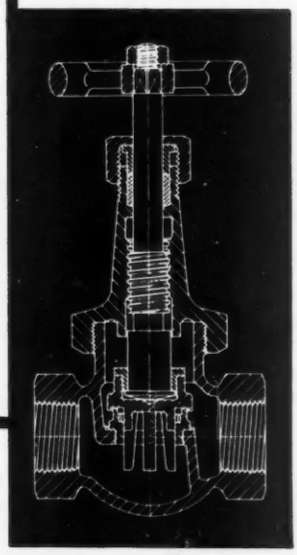

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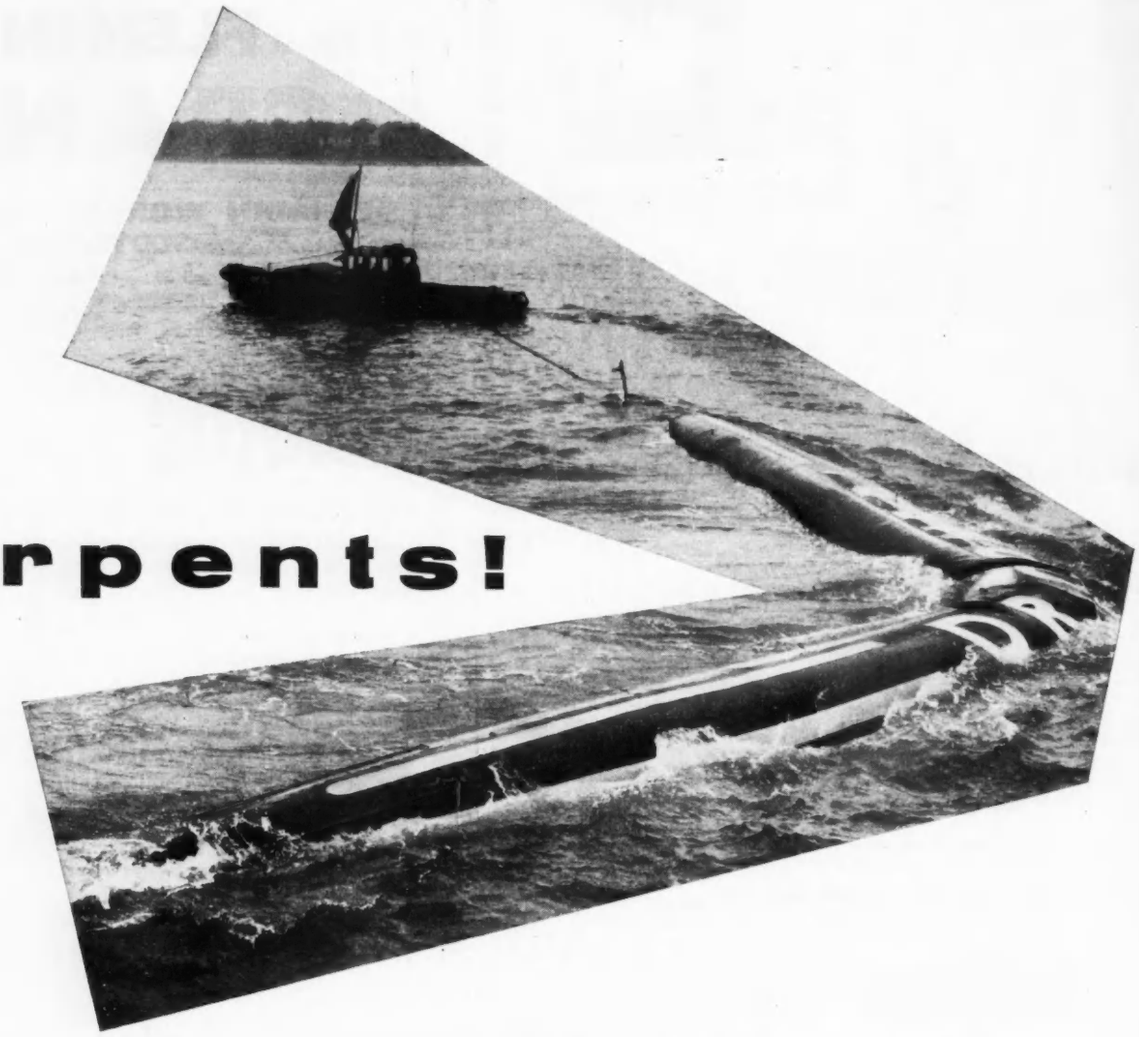

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The largest disc brake in the world

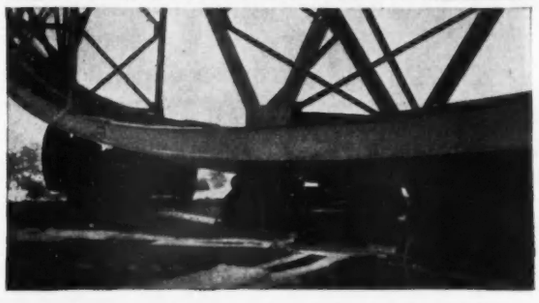
The world's largest Radio Telescope at Jodrell Bank depends upon Ferodo brake linings for the smooth, precise control of its reflector bowl inclination.

The gigantic steel structure has two 180ft. towers. These carry the 250ft. diameter bowl weighing 750 tons which can be tilted into a vertical position in either direction, or completely inverted.

The telescope has the equivalent of both a foot brake and a parking brake. The foot brake, lined with Ferodo MR.41 friction material, operates through four pairs of lorry wheels on standard transport axles, turned upside down so that the wheels press against the 300ft. diameter 'bicycle wheel' stabilising track fixed behind the reflector bowl.

The parking brake is the largest disc brake in the world, designed to hold the massive revolving bowl firmly in position even in gale-force winds. It consists of two jack-operated clamps mounted in tandem and lined with 32″ x 6″ strips of Ferodo BA material.

Ferodo friction materials have been proved in industry to give the smoothest, safest stopping power. *If you have a friction problem*—as the designers of the Jodrell Bank Radio Telescope had—why not call in Ferodo?



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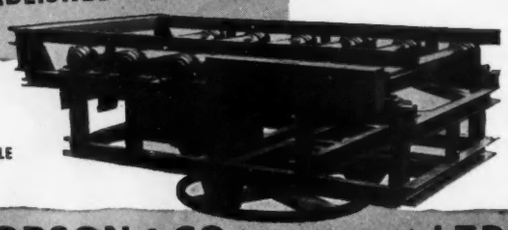

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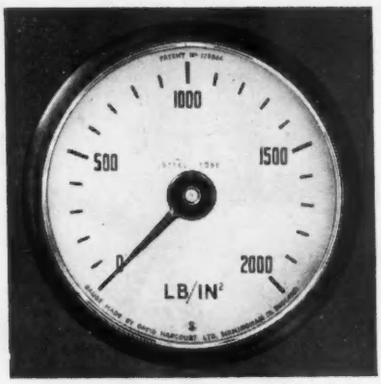

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This patented unit is recommended for the more important installations. It is available with four mountings as illustrated below with 4in. and 6in. diameter dials.
Large illustration and 2.
Narrow flange, with rear clamp fixing.
This model has a black, shock-resisting plastic case.
(1) Flush fitting, with back connection.
(3) Surface mounting, with bottom connection.
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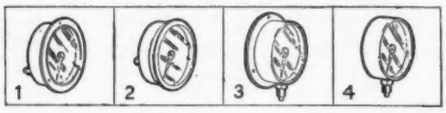

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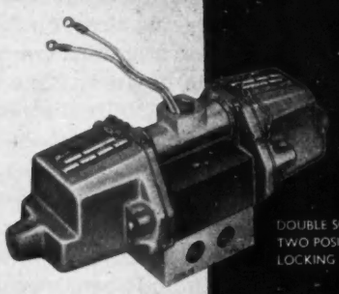

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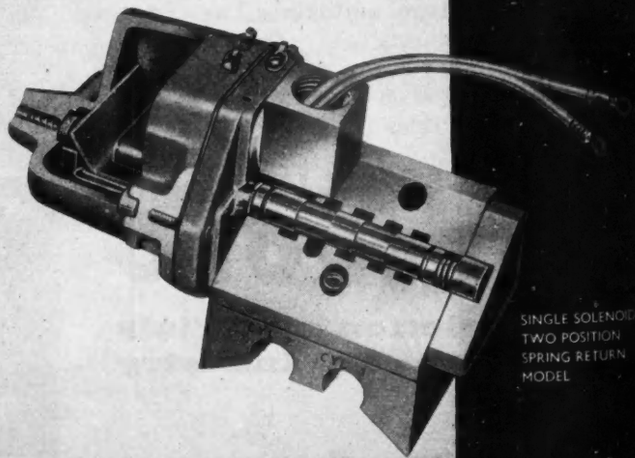

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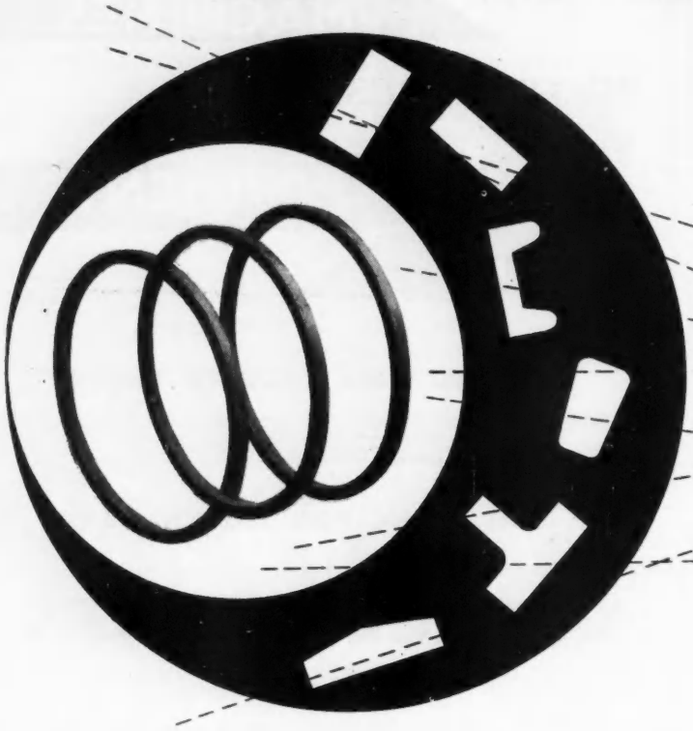

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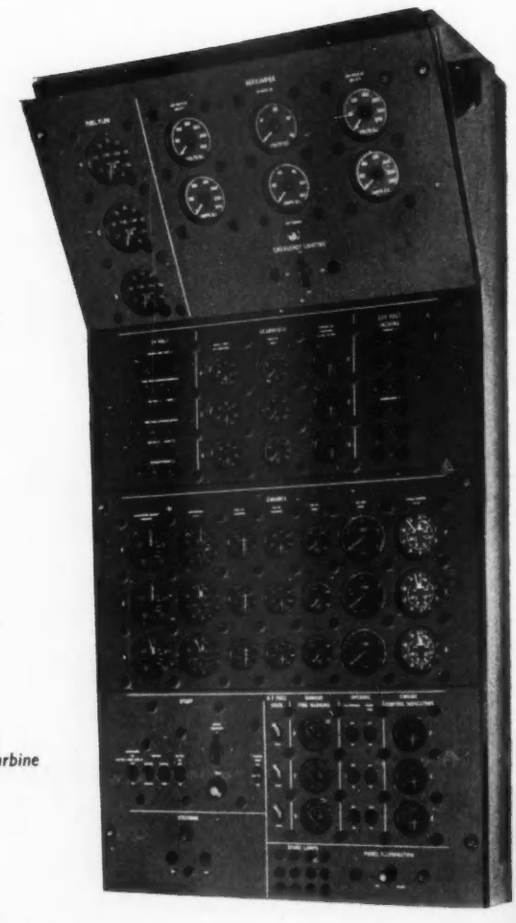

Engineer's Control Panel as fitted in Fast Patrol Boats incorporating Instrumentation for Rover Gas Turbine Generators, Fuel Flow Meters, Main Propulsion Gearboxes and three Bristol Proteus Gas Turbines.

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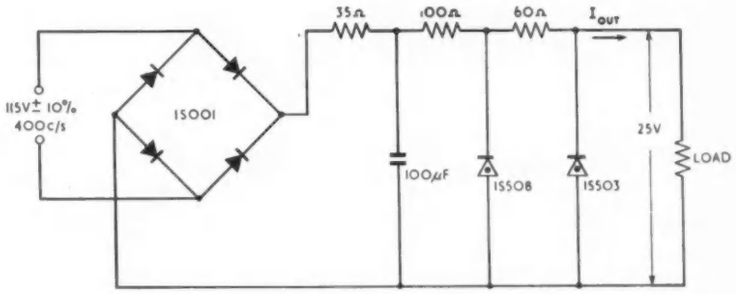
type	zener voltage Vz @ Iz volts	zener current Iz mA	zener impedance Zz (max) @ Iz ohms	reverse current Ilb @—10V 25° C μA	power dissipation P (max) Ts—50°C watts	typical temp. coefficient %/°C
IS501	22	150	4	10	8	0.08
IS502	24	150	4	10	8	0.08
IS503	27	150	4	10	8	0.08
IS504	30	150	5	10	8	0.08
IS505	33	150	5	10	8	0.08
IS506	36	150	6	10	8	0.09
IS507	39	150	6	10	8	0.09
IS508	43	100	7	10	8	0.09
IS509	47	100	8	10	8	0.09
IS510	51	100	10	10	8	0.10
IS511	56	100	11	10	8	0.10
IS512	62	50	14	10	8	0.10
IS513	68	50	16	10	8	0.10
IS514	75	50	24	10	8	0.11
IS515	82	50	26	10	8	0.11
IS516	91	50	40	10	8	0.12

Actual Size



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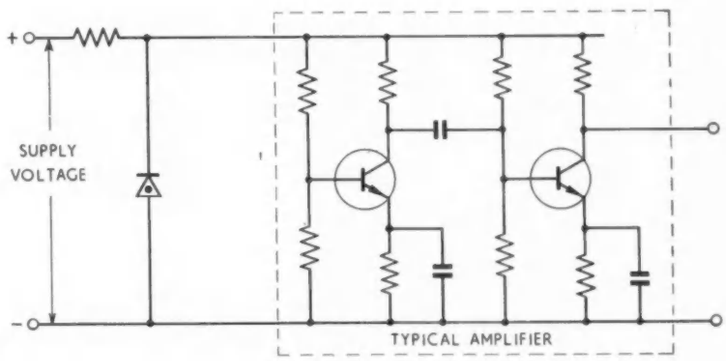

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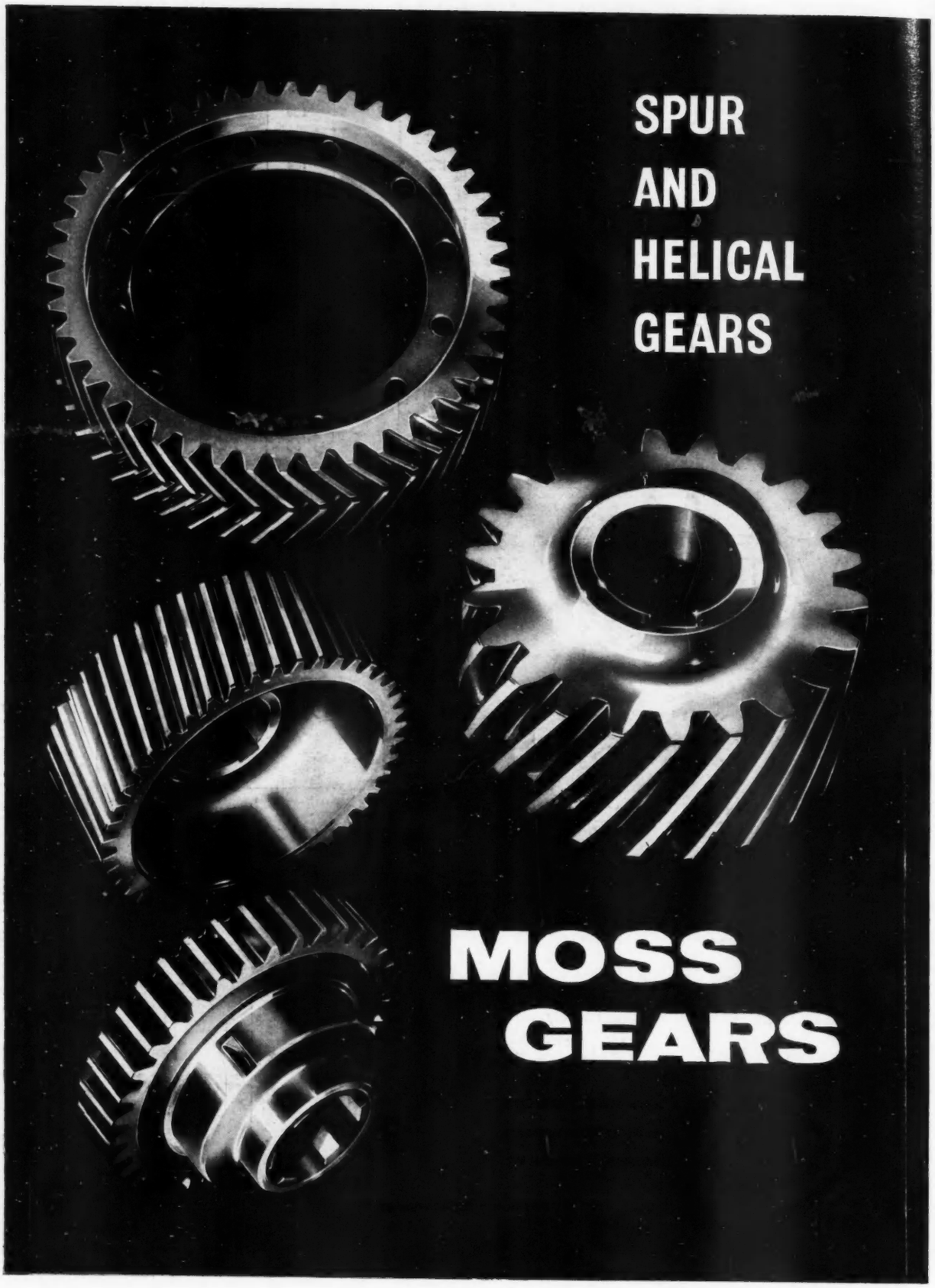

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